# NAVAL POSTGRADUATE SCHOOL
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# THESIS

**AN ANALYSIS OF AUTOMATIC IDENTIFICATION TECHNOLOGY APPLICATIONS IN NAVAL LOGISTICS**

by

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March 1997

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This thesis evaluates potential uses of automatic identification technologies (AIT) in support of Naval logistics. AIT includes a range of technologies and techniques which incorporate the rapid and accurate capture of data and its subsequent processing for cognitive recognition and identification. An introduction to the various AIT system components, from the well established bar coding technology to the more versatile radio frequency identification (RFID) technology, is presented. Additionally, the underlying fundamentals of Naval logistics principles, functions, and elements are discussed, including how these themes translate into promising potential uses of AIT. Recent Naval AIT applications are featured and the results and lessons learned evaluated. In this era of joint operations and use of coalition forces, this work places emphasis on compatibility, interoperability, and the importance of enforcing standardization of AIT symbologies in the commercial and military sectors. The DoD is in the midst of great change and restructuring, especially in the area of logistics. This study provides Naval logistics stakeholders a broad overview of the prevalent AIT system component capabilities and limitations. An AIT implementation model is also featured that delineates the various program elements which have significant impact on the efficiency and effectiveness of procured AIT systems. A thorough understanding of the technology and its associated integration issues should enable Naval leadership to make sound AIT acquisitions.

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# AN ANALYSIS OF AUTOMATIC IDENTIFICATION TECHNOLOGY APPLICATIONS IN NAVAL LOGISTICS

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## ABSTRACT

This thesis evaluates potential uses of automatic identification technologies (AIT) in support of Naval logistics. AIT includes a range of technologies and techniques which incorporate the rapid and accurate capture of data and its subsequent processing for cognitive recognition and identification. An introduction to the various AIT system components, from the well established bar coding technology to the more versatile radio frequency identification (RFID) technology, is presented. Additionally, the underlying fundamentals of Naval logistics principles, functions, and elements are discussed, including how these themes translate into promising potential uses of AIT. Recent Naval AIT applications are featured and the results and lessons learned evaluated. In this era of joint operations and use of coalition forces, this work places emphasis on compatibility, interoperability, and the importance of enforcing standardization of AIT symbologies in the commercial and military sectors. The DoD is in the midst of great change and restructuring, especially in the area of logistics. This study provides Naval logistics stakeholders a broad overview of the prevalent AIT system component capabilities and limitations. An AIT implementation model is also featured that delineates the various program elements which have significant impact on the efficiency and effectiveness of procured AIT systems. A thorough understanding of the technology and its associated integration issues should enable Naval leadership to make sound AIT acquisitions.

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## LIST OF ACRONYMS

| | |
|---|---|
| ADC | Automatic Data Collection |
| AIP | Acquisition Improvement Program |
| AIT | Automatic Identification Technology |
| AM | Amplitude Modulation |
| AMS | Automatic Manifest System |
| ANSI | American National Standards Institute |
| ASCII | American Standard Code for Information Exchange |
| ATM | Automatic Teller Machine |
| bpi | bits per inch |
| bps | bits per second |
| CASCOM | Combined Arms Support Command, Army |
| CCD | Charge-Coupled Device |
| CFS | Container Freight Station |
| CINCLANTFLT | Commander in Chief, Atlantic Fleet |
| CIM | Corporate Information Management |
| CINCUSACOM | Commander in Chief, U. S. Atlantic Command |
| CMS | Communications Security Material |
| CONUS | Continental United States |
| COTS | Commercial Off the Shelf |
| CPU | Central Processing Unit |

| | |
|---|---|
| DARPA | Defense Advanced Research Project Agency |
| DLA | Defense Logistics Agency |
| DoD | Department of Defense |
| DSDC | DLA System Design Center |
| DSMC | Defense Systems Management Glossary |
| DTS | Defense Transportation System |
| EPA | Environmental Protection Agency |
| FAA | Federal Aviation Administration |
| FCC | Federal Communications Commission |
| FISC | Fleet and Industrial Supply Center |
| FM | Frequency Modulation |
| FTP | File Transfer Protocol |
| GAO | Government Accounting Office |
| GCCS | Global Command and Control System |
| GMT | General Military Training |
| GPS | Global Positioning System |
| GSA | Government Services Agency |
| GTMO | Guantanamo Bay Cuba |
| GTN | Global Transportation Network |
| HAZMAT | Hazardous Material |
| HCI | Hitachi Cable of Indiana |
| HF | High Frequency |

| | |
|---|---|
| IBV | In the Box Visibility |
| IEEE | Institute of Electrical and Electronics Engineers |
| ILS | Integrated Logistics Support |
| ILSP | Integrated Logistics Support Plan |
| IPR | In Progress Review |
| IPT | Integrated Product Teams |
| ITV | In Transit Visibility |
| JCS | Joint Chief of Staff |
| JDTAV | Joint Defense Total Asset Visibility Office |
| JIT | Just-in-Time |
| Kb | Kilo bytes |
| Kbps | Kilo bits per second [3] |
| Khz | Kilo Hertz |
| LCC | Life Cycle Cost |
| LF | Low Frequency |
| LED | Light Emitting Diode |
| LOG-AIS | Logistic Automated Information System |
| LOGMARS | Logistics Application for Marking and Reading of Symbols |
| LMI | Logistics Management Institute |
| LSA | Logistics Support Analysis |
| LSAR | Logistics Support Analysis Record |
| MAMS | Maintenance Assistance Modules |

| | |
|---|---|
| MARC | Multi-Technology Automated Reader Card |
| MDRS | Mobile Detection Assessment Response System |
| MF | Medium Frequency |
| Mhz | Mega Hertz ($10^6$) |
| MIS | Management Information Systems |
| MITLA/RF | Microcircuit Technology in Logistics Applications Radio Frequency |
| MRHA | Multiple Robot Host Architecture |
| MSDS | Material Safety Data Sheets |
| NALCOMIS | Naval Aviation Logistics Command Management Information System |
| NAMO | Naval Aviation Maintenance Office |
| NATO | North Atlantic Treaty Organization |
| NAVAIR | Naval Air Systems Command |
| NAVSUP | Naval Supply Systems Command |
| NCCOSC | Naval Command Control and Ocean Surveillance Center |
| NDP | Naval Doctrine Publication |
| NEO | Non-Combatant Evacuee Operation |
| NIST | National Institute of Standards and Technology |
| OCONUS | Out Continental United States |
| OCR | Optical Character Recognition |
| O&M | Operations and Maintenance |
| OMC | Optical Memory Card |

| | |
|---|---|
| OSD | Officer of the Secretary of Defense |
| PDF | Portable Data File |
| PM | Program Manager |
| POD | Port of Debarkation |
| POV | Privately Owned Vehicle |
| PPBM | Positive Passenger Baggage Matching System |
| PIN | Personal Identification Number |
| PMS | Preventive Maintenance System |
| PVC | Polyvinyl Chloride |
| PWC | Public Works Center |
| R&D | Research and Development |
| RIC | Remote Intelligent Communications |
| RF | Radio Frequency |
| RFDC | Radio Frequency Data Communication |
| RFDC/ID | Radio Frequency Data Communication / Identification |
| RFID | Radio Frequency Identification |
| RPS | Roadway Package Systems |
| SAVI | Savi Technology, Inc., of Mountain View, CA |
| SBA | Small Business Association |
| SBIR | Small Business Innovation Research |
| SRC | Scheduled Removal Card |
| SRC | Systems Resource Center, Inc. |

| | |
|---|---|
| SSN | Social Security Number |
| STTR | Small Business Technology Transfer |
| SWIFT | Service Wide Intermodal Freight Tracking System |
| TAV | Total Asset Visibility |
| UPC | Universal Product Code |
| USTRANSCOM | United States Transportation Command |
| VR | Voice Recognition |
| WPS | World Wide Port System |
| WWW | World Wide Web |

# I. INTRODUCTION

## A. OVERVIEW

Since the fall of the Berlin Wall and the collapse of the Soviet Union, the U.S. Armed Forces have undergone a "right sizing" process, coinciding with a further reduction in the Defense budget. Every area of military operations has been scrutinized, including logistics. Yet, despite their importance, support functions still appear to be likely targets for budget cuts. In short, the military must do more with less. This has led to a renewed focus on re-engineering, streamlining, and increasing the efficiency of supply chains. A result has been to develop new business practices which include a much greater dependence on, and partnership with civilian industry and commercial service providers. Emerging from these joint efforts is an expanded use of automatic identification technologies (AIT). Consequently AIT could be a vital ingredient to future Naval logistics mission success through "Providing and sustaining our operational readiness by getting the right support to the right place at the right time." [Ref. 1: p. 6]

AIT is not a recent breakthrough in the logistics arena. Over several years, commercial and military organizations have realized the benefits of its use in numerous applications ranging from materials handling to billing. However, as with any emerging technology, AIT capabilities continue to expand, and with this expansion come new uses for AIT never before thought possible.

AIT is comprised of a variety of technologies. These include: linear bar-codes, two-dimensional bar codes, optical character recognition (OCR), magnetic stripe, smart

cards, optical laser cards, voice recognition, and radio frequency identification (RFID). Of these technologies, the military has made most frequent use of bar-codes, optical laser cards, and more recently, RFID. But as technological advances enable equipment to become smaller, less expensive and more durable, with increased data storage capacity, AIT is destined to play a more central role in future military logistics.

The military's need for expansion of AIT capabilities grew out of the lessons learned from the Gulf War. Due to rapid deployment of war material to theater destinations, relevant documentation often did not accompany shipments. As a result, more than half the containers shipped to the Middle East had to be opened in order to determine their contents. From these difficulties the initiative for total asset visibility and intransit visibility (TAV / ITV) was born. TAV / ITV is supported by AITs such as laser cards and RFID devices.

Although "asset visibility" in the Defense Transportation System is emerging as the major user of current AIT capabilities, military uses of the technology continue to expand. Automatic manifesting, tracking of maintenance returns, theater-level stock management, and real time monitoring of security force personnel are just a few examples of AIT's potential as a force multiplier in current and future military scenarios.

Despite its increasing role in military logistics, not all services have completely embraced AIT. The Army, Air Force, and the Marine Corps have all developed proven AIT programs. The Navy, however, is just now beginning to explore uses for the technology. The objective of this research; therefore, is to examine current DoD and civilian AIT initiatives and subsequently propose those applications that would most

benefit the functional areas of Naval logistics: supply, transportation, health services, maintenance, engineering, and other services (administration, billeting, disbursing, food and postal services).

## B. RESEARCH OBJECTIVES

This thesis examines the functional areas of Naval logistics and assesses how to use AIT to improve and expand those operations. This thesis also seeks to answer the following questions:

- What are the performance characteristics of existing AIT systems?
- How is private industry utilizing AIT to improve logistics?
- What functional areas of Naval logistics does AIT currently support?
- What are some potential AIT applications in Naval logistics?
- What are the systemic barriers preventing effective and efficient implementation of AIT in the Navy?
- Given these issues, what should be the implementation strategies for AIT in Naval Logistics?

## C. SCOPE AND LIMITATIONS

The current and future applications of AIT are vast throughout the DoD. This thesis, however, focuses strictly on AIT applications in the United States Navy. It is further limited in the support of the functional areas of Naval logistics. Radio Frequency Identification technology for reasons explained in Chapter II, is the most robust of the automatic identification technologies and hence receives expanded coverage. Six other technologies are briefly discussed for comparative analysis and to provide the reader with a cogent overview of AIT.

A significant and real world constraint that has hampered this research is the rapid and continuous evolution of this technology. It is inevitable that there will be significant advances in some of the AIT components in terms of capacities, capabilities, and costs. Furthermore, AIT development within the Navy versus the other services, is in its early stages, which equates to limited availability of published test data. Nevertheless, the strategies, principles, and objectives detailed in this thesis should in the near term remain germane.

## D. METHODOLOGY

The primary method of obtaining research material was through extensive review of existing literature and on-line resources. The on-line resources proved to be an absolute necessity as AIT is evolving at an incredible rate. Additional research material was gathered from an actual field demonstration report from the Water Freight Terminal, Fleet and Industrial Supply Center (FISC), Norfolk, Virginia. Valuable insight was obtained through phone interviews and electronic transmissions with key DoD agencies such as, Navy Staff (OPNAV, N4), Naval Supply Systems Command (NAVSUP, N4) who spearheads the AIT steering committee for the Navy, and Commander in Chief, Atlantic Fleet (CINCLANTFLT, N4).

The researchers also used their operational experience from the Surface Line, Supply Corps, and Fleet Support communities as guiding precepts in the formation of AIT implementation strategies. The researchers' operational experiences yielded valuable "user perspectives" that define the need for which future AIT systems will evolve from concept exploration to full development.

## E. THESIS ORGANIZATION

This thesis is divided into six chapters. Following this overview chapter, Chapter II provides an analysis of the primary AITs coupled with a more detailed analysis of Radio Frequency Identification (RFID). Chapter III investigates the commercial and military applications of AIT. Chapter IV summarizes United States Naval logistics doctrine and examines how the Navy is employing AIT in support of the primary functional elements. Chapter V suggests AIT implementation strategies for the Navy. The final chapter contains a summary, AIT issues and recommendations, and recommendations for further research.

# II. AUTOMATIC IDENTIFICATION TECHNOLOGY

## A. INTRODUCTION

This chapter discusses the principle types of automatic identification; why there is a need for AIT, how the various technologies operate, some of their costs and manufacturers, and the strengths and weaknesses of each. After discussing the first seven AITs (linear bar codes, two-dimensional bar codes, magnetic stripe, optical character recognition, smart cards, optical laser cards, and voice recognition), a more thorough discussion on RFID technology is presented.

## B. THE NEED FOR AUTOMATIC DATA COLLECTION (ADC)

Virtually every manufacturing company needs solid, consistent data about their manufacturing operation so they can make sound judgements about how to improve it. Whether the goal is to increase production capacity, decrease costs, or improve quality, the first step is to accurately monitor the current manufacturing process. An automatic identification system will improve data collection precision while decreasing the time spent by direct labor personnel to gather the information management needs, freeing them to build product. [Ref. 2: pp.1-9]

The primary benefit of automatic data collection (ADC) is timely, accurate data collection. Traditional collection methods produce error rates ranging from one in thirty for handwritten documents to one in three hundred for keyboard input. Automatic identification systems operate in the accuracy range of one error in three million entries, and most offer audible entry feedback for immediate error correction [Ref. 3: p. 55]. No

company or organization, if they want to stay competitive, can afford to do a job twice. Therefore, ADC can be a useful tool in developing a successful business organization. When ADC is properly implemented into a business, costs can be reduced, the business will become more competitive, and an increase in customer service levels should result. [Ref. 4]

As stated in the previous chapter, AIT is comprised of a variety of technologies. The following sections will discuss the most prevalent AITs used in commercial and military applications. Major system components are detailed and an overview of the inherent strengths and weaknesses of each technology is provided.

## C. LINEAR BAR CODES

### 1. The Technology

Although all bar codes appear to look pretty much the same, there is actually a variety of code types called symbologies. The types are created to handle different sets of data for specific applications. The most common symbology is the Universal Product Code (UPC), which is widely used in retail operations. Other symbologies are code 39, which is endorsed by the automotive, health, and defense industries; and interleaved 2 or 5 symbology, which is the type commonly used on UPC labels attached to the outside of shipping cartons and containers. [Ref. 5: p. 94]

Regardless of the symbology, all bar codes are basically patterns of lines and white spaces of varying width representing alphanumeric characters. The encoded data is printed directly on items and surfaces, or on labels affixed to the product or packaging. The characters in a bar code are read by an optical scanner, which contains a source of

intense light (usually a laser or emitting diode) that is aimed at the pattern of lines and spaces; the dark bars absorb the light, and the white spaces between the bars reflect the light. The resulting pattern of light and dark is measured by a decoder in the scanner, then translated into a binary code and transmitted to a computer. [Ref. 6: p. 2]

A typical bar code system consists of labels, scanner (reader), decoder, and processor. Bar code labels have to be printed quite carefully and exactly, since bar code scanners and decoders are not very forgiving. The most important bar code printing consideration is sufficient contrast between the marking medium (primarily ink) and substrate. Inadequate contrast between bars and spaces render the label unreadable, or reduces the probability of a successful scan. Inks should have a low degree of specularity (matte finish), since glossy inks tend to reflect the beam back into the scanner, making the bars appear to be spaces. Bar codes covered with a highly reflective film, such as cellophane or clean packing tape, produce a similar effect. Special omnidirectional scanners which create parallel scan lines at different incident angles to the bar code are available to handle these highly specular applications. [Ref. 5: p. 96]

Bar code scanners come in two broad categories: contact and non contact. The most common and typically least expensive option is the contact wand. An LED sensor inside the wand reads bar codes it is passed across by detecting the relative reflectivity; it passes on that information for decoding and processing. The wand's advantage is its high performance to cost ratio. As a contact device that also depends on operator skill to manually sweep the wand over the bar codes, it may not always be the scanner of choice. In a relatively low throughput, comfortable environment, a contact wand is satisfactory.

The non contact scanner-be it laser, LED, or CCD (charge-coupled device) has significantly greater throughput and flexibility, and provides practical automation in environments where it is difficult, dangerous, or impossible to get close enough to touch the bar code label. Operating distances range from a few inches (for the CCD) to several feet (for the lasers). [Ref. 2: pp. 1-3]

Often a part of the scanner subsystem, the decoder translates the information gathered by the scanner into information that is usable by the rest of the system. Here the decoding algorithms turn the scanner's output into normal computer data for processing. These decoding algorithms, more so than the scanners, are responsible for the accuracy of a bar code system. Most of all commercially available bar code systems now operate with relative flawlessness [Ref. 2: pp. 1-3]. The decoder may be contained in the scanner housing or be a separate unit, depending on the application. A self contained decoder is usually more economical for an application requiring a single read and transmission, with a few relay outputs. In other cases, centralized decoding from multiple scan heads is less expensive. [Ref. 5: p. 95]

The processor can be a personal computer, a mainframe, or a handheld data collection device. All have the ability to process bar code data.

### 2. Strengths

Linear bar code technology offers the following strengths:

- Availability and low cost - Printed labels and scanners are offered by numerous manufacturers and are relatively inexpensive.
- Accuracy - Data capture is nearly error free compared to manual data entry.

- Ease of use - Front line users require only limited training in the operation of bar code scanners. Additionally, linear bar codes can be easily produced with laser printers and off the shelf computer utilities.

- Portability - Portable scanners allow the user to go to the product which may be too large to move to a stationary scanner or the item may not be easily retrievable by material handling equipment. Conducting periodic material inventories with a portable scanners is a prime example of its portability.

- Standardization - Setting firm standards improves interoperability. The first bar code standards for retailing were set as far back as 1973 in the US, and in Europe in 1977. [Ref. 7: p. 50]

#### 3. Weaknesses

Obvious bar code disadvantages are the need for line of sight readings and the fact that new labels are required if the data is to be modified [Ref. 7: p. 50]. They can only accommodate a small quantity of information - 9.4 to 17.8 characters per inch [Ref. 8: p. B-4] and they are sensitive to environmental conditions such as dirt, rain, snow, ice, heavy handling, and fading [Ref. 2: p. 3-17]. All these environmental factors can degrade the performance of bar code technologies.

Because linear bar codes are easily produced and may be photocopied, security is also an issue. Individuals in possession of the proper characters and symbologies have the potential to compromise the technology's intended use.

### D. TWO-DIMENSIONAL (2-D) BAR CODES

#### 1. The Technology

Because bar codes are inscribed in a horizontal arrangement, they have to be extended several inches to communicate a substantial amount of information. 2-D codes

were introduced to counter the space limitations of linear bar codes. They use both the x and y axes to convey encoded data.

Most linear bar code applications function on the "license plate" approach, which means the bar code serves as only the item identifier. For example, a UPC bar code found on retail products contains coded information on the manufacturer and product. However, the product description, inventory information, and price remain in the retailer's computer. Today, 2-D codes allow the data contained in bill of ladings to be compressed into an area the size of a postage stamp. At any point in the distribution chain, detailed information about the product's contents can be retrieved with a wave of portable scanner. [Ref. 9: p. 91A]

Like linear bar codes, 2-D codes come in a variety of symbologies and formats. There are presently sixteen 2-D symbologies. Four of the most established public symbologies are PDF 417, MaxiCode, Code One, and Data Matrix. PDF 417 was developed in 1989 and is the most utilized. As many as 1,850 alphanumerical characters or 2,710 numerical digits can be stored on one symbol. MaxiCode is a one inch square symbol that can hold up to 100 characters. It was developed by UPS in 1989 but has since gone public. The MaxiCode symbol looks like a honeycomb pattern with a bull's eye in the middle. The bull's eye design enables ease of scanning from any direction. Code One is renowned for its capacity; the smallest dot size pattern can bundle 2,088 alphanumeric characters into one square inch. A Data Matrix symbol looks like a large square composed of smaller squares. It can bundle as many as 500 numeric characters in the space of an 0.110 inch. [Ref. 10: p. 76S]

### 2. Strengths

2-D codes are intended for labeling small objects such as single doses of medication upon which the amount of data cannot be effectively represented with linear bar codes. [Ref. 9: p. 96A]

Due to its large capacity, shipping data could be attached on any package and this in effect could serve as a portable data file that stays with the package. Two dimensional codes offer portability to any user who incorporates this technology into their business. [Ref. 10: p. 76A]

Other 2-D code strengths :

- Label can be readable even when partially destroyed
- Supports data encryption
- Can be printed on paper, vinyl, polyester, Keflar, or aluminum
- Not susceptible to electromagnetic or electrostatic interference. [Ref. 8: p. B-5]

### 3. Weaknesses

- None of the codes can be read with conventional scanners used on linear bar codes. They also require different software and printers.
- None of the sixteen symbologies have been accepted as a standard. [Ref. 10: p. 75S]
- 2-D technology is not yet well developed and as such there are only a small number of vendors who offer 2-D products. With more time, enhancements, and business manager awareness, 2-D technology has great potential to improve business's productivity.

## E. MAGNETIC STRIPE

### 1. The Technology

Magnetic stripe technology has been in use since the 1960's and is used almost exclusively in the security and financial industries. Automated Teller Machine (ATM) cards, which use magnetic stripe technology, are used pervasively and conveniently throughout the world.

The magnetic stripe is made up of tiny permanent bar magnets called "domains". Each domain is about twenty millionths of an inch long. These bar magnets are mixed into a binder (paint) and shaped into a "slurry." Before the slurry dries, the magnetic particles are polarized so they can be encoded with data by the card issuer. The slurry can be attached to virtually any material but is most commonly attached to polyvinyl chloride (PVC). The magnetic stripe holds information within tracks on the slurry [Ref. 11]. A single magnetic stripe contains three low level density tracks for data, and it can record a significantly higher quantity of information than bar codes or optical character recognition (OCR). [Ref. 6: p. BG2]

Reading data from a magnetic stripe card can use devices such as manual swipe/insert readers. To read or encode data from a "magstripe", the magnetic head must be in physical contact with the magstripe. [Ref. 11]

### 2. Strengths

There is a world wide industry standard for magnetic stripe data encoding. Therefore, cards coded on a machine made by one manufacturer can be read on any machine conforming to the standard. It is difficult to copy magstripe cards and they are

therefore a good option for security transmission applications - personnel credit cards for example [Ref. 2: p. 1-14]. Magstripe has the advantages of being durable and it gives accurate first time readings. Lastly, it has the potential to be rewritten or erased as necessary. [Ref. 7: p. 52]

### 3. Weaknesses

Magstripes scanning stations called "card readers" require good alignment between reader and stripe. Card readers must also have some type of mechanical assistance, effectively eliminating handheld magnetic scanners. Accordingly, magstripes cannot be attached to the exterior of packages like bar codes can [Ref. 2: p. 1-14]. A magstripe user must take out the card, scan it, then return it to its origination. This practice is more labor intensive than a bar code system that requires one sweep of the scanner.

Magstripes, like other magnetic media, is susceptible to strong electromagnetic fields and must therefore be protected. Credit cards have been ruined when they have been exposed to high radio frequency emitting devices. Finally, tracks one and three can record up to 210 bits per inch; track two can store up 70 bpi. Therefore, although Magstripe data capacity is larger than linear bar codes, it is still quite bounded. [Ref. 2: p. 1-15]

## F. OPTICAL CHARACTER RECOGNITION (OCR)

### 1. The Technology

Where human readable labels are required, or when typed data needs to be captured directly from the documents, Optical Character Recognition (OCR) scanners are

used [Ref. 7: p. 50]. OCR scanners acquire the printed page into a bit map image and then into ASCII characters via OCR software. The OCR process takes an image and matches it to a sophisticated algorithm. The ASCII characters can then be imported into a specified document.

Accuracy for translating characters is what OCR is bench-marked against. Current programs can provide 99 percent and higher recognition rates. However, there are variables for the use of any technology. For example, the type of font, quality of the original image, or whether the scanner is handheld or flatbed in design can make it more difficult to distinguish characters. OCR systems become more useful when their accuracy rate approaches 100 percent. A lower accuracy rate demands that more time will be spent correcting the document. [Ref. 12]

### 2. Strengths

OCR technology affords users savings in labor hours since it is far quicker and more accurate than keyboard entry. Data collection for payment recording (e.g., electricity bills) is a common practice [Ref. 7: p. 52]. Since OCR codes can be read by people, double labeling is not required - i.e., one label attached for ease of customer product identification and the other for computer recognition.

OCR readers coupled with improving software will allow the user to preclude entering previously typed documents. Many businesses still operate in a paper environment and OCR technology will greatly minimize the time it takes to transform " hard" documents into computer paperless media.

### 3. Weaknesses

There are drawbacks in terms of reading accuracy, speed, and range. Additionally, not all type fonts can be read [Ref. 7: p. 50]. OCR is primarily a contact technology; to read OCR characters the user has to sweep the wand over them. Because of the relative sensitivity of the OCR decoding systems, OCR printing must adhere to fairly stringent guidelines to be successfully scanned. Although accuracy rate is high (though not as high as bar codes) the first read rate is substantially lower. That means more dependence on operator performance which is difficult to control. [Ref. 2: p. 1-4]

## G. SMART CARDS

### 1. The Technology

Smart cards, or credit cards with a computer chip, have the capability to store hundreds to millions of bytes of information. They have the capacity to store and rewrite information directly to the card. However, the thickness is greater than that of a credit card due to the packing of the of electronic components. The Japanese developed the technology in 1970, but it was the French who capitalized its use. Currently sixty percent of the French population use smart cards on a daily basis. [Ref. 13]

Smart cards have a plastic "brain" with a small scale computer inside. Every card contains a computer chip, memory, CPU, and its own operating system. The crudest of cards are electronic memory stores. Some cards can receive data only once, while others can read, write, and erase data from the card.

Smart cards are classified into three main families, automata (calling card used by the French), microprocessors with simple data management, and microprocessors with

high level data management. Applications include the information storing of health record data, financial information for point of sale transactions, passports, driver's licenses, mass transit access, frequent flyer miles, and student identification. [Ref. 13]

### 2. Strengths

Used mainly in banking and security environments, smart cards provide protection against fraudulent use that far surpasses traditionally encoded credit or pass cards. Some cards will also deactivate if the incorrect pass word is entered. Smart cards can contain general data about its owner eliminating the need for multiple credit, bank, and identification cards. The cards also have the ability to protect the information they carry with traditional personal identification numbers (PINs). They can also check against a bank balance to avoid over charged accounts. [Ref. 13]

### 3. Weaknesses

Smart cards have made a greater impression in Europe than in the United States primarily due to a prior existence of an extremely sophisticated credit network across the U.S. [Ref. 2: p. 1-6]. Due to limited production, the cost of smart card technology is relatively high [Ref. 14: p. 43]. In addition, smart cards are made of the same basic material as the magstripe and when exposed to extreme environmental conditions they are adversely affected.

## H. OPTICAL LASER CARDS

### 1. The Technology

The optical laser card, which is similar to the smart card, is credit card sized but has the data capacity to store 4.8 megabytes of data and six megabytes is on the near

horizon. With this capacity, the cards are well suited for a variety of medical applications. The personal identification industry sees great potential for the laser card. Biometric images such as fingerprints, voice prints, and retinal scans require storage of about 250 KB, and laser cards are the only media available to accommodate the large data specifications. [Ref. 15: p.169]

The core technology is the same as that used in compact disks. On both sides of each laser card there is a one millimeter thick protective coating that encapsulates the recording surface. Information gets recorded on the card using a laser beam focused on the recording surface. The laser digitally "writes" information to the recording surface by imprinting a series of light and dark areas on the disk. In order to read a optical laser card, a user needs a laser scanner which detects light and dark reflections from the metalized surface and interprets the reflections as digital data. [Ref. 16: p. 27]

### 2. Strengths

The strengths of this technology are derived from its small size, durability and large data storage capacity. The cards provide a non erasable audit trail that can withstand rough treatment and environmental extremes while at the same time affording the user capability to update the card via microcomputer. [Ref. 17: p.34]

### 3. Weaknesses

A weakness of this technology is the relatively high cost (five to eight dollars per card) when compared to a bar code (\$.10 - \$.25) and magnetic stripe (\$.85 - \$1.50) [Ref. 14: p. 34]. Laser cards, when used in an automated manifest system (AMS), requires a trained user to operate both a scanner and personal computer [Ref. 17: p. 169]. As with

any new developing AIT, there are growing pains and the quest for setting standards will challenge the industry. [Ref. 15: p.171]

## I. VOICE RECOGNITION (VR)

### 1. The Technology

Voice recognition technology verifies an individual's identity by analyzing their unique voice print [Ref. 18]. VR data collection systems work best when the end-user is unable to use his or her arms when performing a task. The two broad categories of VR are speaker dependent and speaker independent systems. Before speaker dependent systems can be used the user must develop a grammar file. This file is a list of numbers, words, and/or phrases stored in the appropriate VR computer. Speaker independent systems can understand the end-user without setting up a grammar file.

The different number of and quantity of characters, words, and phrases that a VR system can handle can be correlated to the amount of memory the host computer has to operate it. VR systems can also be categorized as either continuous, connected, or discrete systems. A continuous system allows strings or sentences of words to be entered at once. Connected voice data entry dictates that end users speak in predefined characters. Discrete systems require speaking one character or word at a time. [Ref. 19]

### 2. Strengths

VR reduces the need for numerical identifiers such as account numbers and personal identification numbers. It should also eliminate consumer fraud. While fingerprinting is almost a foolproof way for personnel identification, it requires that the individual be physically present. VR manufacturers are starting to use voice as another

way to interact with computer based systems. Voice is the fastest and most efficient way of working with computers - especially when working over phone lines. VR has many possible applications such as building security, credit card authentication, forensics, and telephone fraud reduction [Ref. 18]. These systems provide automation capabilities in environments where users need not be computer literate and/or where keyboards or similar input devices are not practical. [Ref. 2: pp.1-5]

### 3. Weaknesses

The cost of VR stations have dramatically decreased in the past few years but as of 1990 systems still cost approximately $6,000 [Ref. 2: p. 17]. Although not necessarily a weakness, the speed of the system is dependent upon the VR user.

## J. RADIO FREQUENCY IDENTIFICATION (RFID)

While RFID is not intended to replace linear bar codes in all applications, RFID should be considered an additional method of AIT that is used alone or incorporated with other methods of data collection. RFID systems were originally developed in 1973 [Ref. 2: p.52] and today are the most technologically advanced method of ADC. RFID technology is about to enter a boom phase. In the past, RFID's acceptance in commercial industry was limited due to high costs and the technology's narrow applicability to many business processes. Consequently, its use was primarily limited to specialized niche markets. Recent developments, however, have reduced RFID implementation costs [Ref. 20: p. 1]. The overview that follows is designed to aid the reader in understanding general RFID system components and characteristics.

### 1. The Technology

RFID systems are composed of three components; an interrogator or reader, a transponder, commonly called a tag, and a computer or other data processing system. With some RFID systems there is no need for contact or a direct line-of-sight between the reader and the tag. This means that the tag can be embedded in or hidden inside objects that need to be identified [Ref. 21]. RFID systems can be classified according to the radio frequency used, the type of RF modulation and the type of tag used with the systems.

#### a. *Operating Frequency*

RFID systems can be classified according to operating frequency as follows:

| | |
|---|---|
| • Low frequency (LF) | Below 500 kHz |
| • Medium frequency (MF) | 500 kHz to 10 MHz |
| • High Frequency (HF) | Above 10 MHz |

LF systems generally have an operating range of between three to fifteen feet and are inexpensive, safe, and license free. Additionally, LF systems do not require line of sight between the tag and the reader antenna.

MF systems operate intermediately between LF and RF systems. Their read range is usually longer than 50 feet but less than 100 yards. These systems also do not require line of sight nor special licensing.

HF systems are available with operating ranges of several hundred yards [Ref. 22: p. 115]. Tags used in these systems tend to use dipole antennas, which are more efficient than the copper windings used in LF tags. Antenna efficiency is important

because the tags use more power to transmit over the same range as compared with LF tags [Ref. 23]. However, the high power supplied to produce the higher end ranges could, if used improperly, harm nearby personnel [Ref. 2: p. 3-38]. HF systems are less acceptable internationally due to licensing difficulties. Plus, these systems which are operating at the high end of the spectrum require line of sight between the tag and the reader unit [Ref. 24: p. 215].

#### b. *Modulation - Transmission Methods*

Two methods of modulation are commonly used in RFID systems; amplitude modulation (AM) or frequency modulation (FM). Depending on the electrical noise in the local environment, more expensive noise resistant transmission techniques must be used. AM is the least expensive but is most susceptible to noise [Ref. 2: p. 3-39]. FM gives significantly improved signal to noise ratio resulting in improved read range and increased reliability of operations [Ref. 24: p. 216].

#### c. *Tag (Transponder) Types*

Tags may be the same shape and size of a credit card, small button, cylinder, or almost any other size and shape. They may be encapsulated, laminated, or embedded in protective materials as well as enclosed in a variety of housing shapes. Active tags have a built in battery that can send back information faster or over a longer distance because they have their own power source to boost the range. On the passive tag, the power needed for the tag to identify itself, or provide encoded information, comes from the reader or interrogator that energizes them.

A further differentiation in tag types is that some are read only and others are read/write. Read only tags contain information that was encoded at the time the code was manufactured or when the tag was first placed in service. Read/write tags have the capability of accepting new data whenever they are reused in a process or when some of their information is acted on, causing it to be erased or changed. This tag coding or writing can be done with a special terminal or done "on the fly" during transfer through a process. [Ref. 2: pp. 6-7]

The main component of an RFID tag is a custom integrated circuit or silicon chip. This chip controls the communication to the reader. The chip has a section of memory that stores the identification code or other data, and the contents of the memory is transmitted to the reader when the chip is activated. The tag has an antenna attached to the chip and a tuning capacitor. The amount of data stored in a tag ranges from eight bits up to sixteen thousand bits of memory. The reader has an antenna to transmit and receive signals. The antenna can be enclosed with the reader electronics or it can be in a separate housing positioned remotely from the electronics. In most RFID systems, the reader emits an electromagnetic field in a zone, the size of which depends on the operating frequency of the system and the size of the antenna. When a tag passes through this zone, the tag detects the signal from the reader and begins to transmit the data stored within the tag back to the reader. [Ref. 21]

### 2. Strengths

- RFID overcomes the limitations of other AITs using light (such as bar codes) because the tag may be placed so that it is hidden or invisible to the eye.

- Readers can be set to read automatically without manually scanning the object as in most bar code systems. [Ref. 23]

- Unlike bar codes, RFID tags can't be easily defaced and rendered unreadable. If appropriately packaged, RFID tags can withstand high temperatures, caustic chemicals, and other hazards that might destroy a paper label. [Ref. 25: p. 30]

- Radio frequencies (RF) propagate through most non-metallic materials (asphalt, cement, wood, plastic), making the muffling of the signal more difficult. Tags, therefore, are still fully operational when placed in or on boxes, in pockets, etc. [Ref. 26: p. 197]

- RFID requires less manpower to present the tag to the reader, in contrast to contact AITs such as bar codes. [Ref. 8: p. B-6]

- A unique advantage of the RFID tag is that it can be programmed to respond when a specific physical condition is not met such as high temperatures in ammunition containers. The tag here serves the purpose of a sensor and will alert the user of potential danger.

- Along with identification, exact locations of the tagged items can be determined. Coupled with a relay to low satellites, RFID applications can be expanded when used with the DoD's Global Positioning System (GPS). The tags have also been tied to the Internet for worldwide access.

- Tags are also being designed with integrated circuits. These "smart" tags can maintain inventory balances, carry large amounts of data, and perform decision analysis. Smart tags have their own energy supply and micro antennas all self contained on a chip.

- RFID is a powerful tool for improving inventory management, particularly in quick response and just in time (JIT) environments. RFID data can be linked to powerful transportation information systems to provide inventory managers with global supply chain visibility in real time. With the addition of simultaneous tag readings, a large warehouse can be inventoried completely in minutes instead of days using bar code scanners. [Ref. 22: p. 116]

### 3. Weaknesses

- In the case of RFID systems used in hazardous areas, additional risks are involved due to electro-magnetic radiation which can induce high currents in conductors or in conductive structures on which they intrude. Examples include active RFID operations in vicinity of ammunition and its potential to interfere with aviation navigation. [Ref. 24]

- Large metallic objects in the area can cause blind spots.

- Adjacent buildings using the same manufacturer's system many experience system irregularities unless facility coding is properly implemented.

- RFID can be electronically jammed. [Ref. 26: p. 197]

- Some HF frequencies are prohibited by various countries. [Ref. 8: p. B-6]

- A major problem remaining is common standards for transmissions, tags, and decoding.

- Each manufacturer's system is still proprietary, therefore, components cannot be mixed and matched. [Ref. 22: p. 115]

This last weakness is perhaps among the top reasons why RFID is not used more pervasively in logistics operations. However, the increasing utility of RFID, combined with decreasing equipment costs and continued progress in standardization, should make RFID the most powerful and versatile AIT since the bar code.

## K. RECENT ADVANCES IN AIT

### 1. Snowflake Code

The Snowflake code is a new type of two-dimensional coding system, which could soon replace bar codes. Instead of a series of lines, the Snowflake code is made up of a pattern of dots which contain information about the product on to which it has been marked. Unlike bar codes, Snowflakes can easily be applied to a wide range of products,

large or small, so small in fact that a Snowflake no bigger than one square centimeter can contain enough dots to represent billions of numbers. Therefore, Snowflakes are able to hold much more information about products, such as details of exactly when and where they were produced which is useful for tracing them either during production or after they have been sold. [Ref. 27]

The code can be applied to products and materials in a wide variety of ways including printed labels, ink-jet printing, laser-etching, indenting or hole punching. However, one major advantage of the Snowflake code is that, regardless of the method of application, the code is very robust and is able to withstand a lot of damage. Up to 40% of the code can be affected by debris, clutter or distortion and still remain readable. [Ref. 27]

### 2. Contact Memory Technology

Contact memory technology has primarily been developed by three companies, Dallas Semiconductor, MacSema and Valgay, whose products share some general characteristics. Contact memory modules consist of a semiconductor memory chip encased in a housing that looks like a watch battery. The memory is accessed by touching a read/write device to the chip housing. Like RFID transponders, memory tags hold more data than standard or 2-D bar codes and are extremely resistant to temperature extremes and environmental hazards. The technology is easier and less expensive to implement than RFID, but the contact requirement makes it unsuitable for some applications. The modules generally resist drops and shock, have more than adequate temperature resistance for outdoor use, have up to 1K of read/write memory and are slightly smaller than a dime

in diameter. The tags are activated by the read/write device and require no power source. [Ref. 28]

Dallas Semiconductor's Touch Memory transponders consist of a semiconductor encased in a 5.8mm thick, 16.3mm diameter stainless steel enclosure, called a MicroCan. A key feature of the technology is that direct contact between the read/write unit is not required for transactions but can be accomplished by contact with a conductive surface that the tag is attached to. For example, tags placed on a metal warehouse rack can be read by touching any point on the metal rack. Range can exceed 100m depending on the conductivity of the surface. [Ref. 28]

### 3. Remote Intelligent Communications Technology

Remote intelligent communications (RIC) units are different form RFID tags in that they have a central processing unit, more memory and a microwave radio on board. This combination allows RIC units to perform more application than RFID units that use older technology and lower frequencies.

Micron Communications, Inc., is a leading manufacturer of RIC products. Its MicroStamp engine combines a direct sequence spread spectrum microwave frequency radio, a microcontroller, and a low power static random access memory into a single chip. Even when coupled with an antenna and a battery, the entire unit is still only the size of a credit card. [Ref. 23]

In one application of RIC technology, Micron has entered into a cooperative research and development agreement with the Federal Aviation Administration to develop a model Positive Passenger Baggage Matching (PPBM) system. The objective of the

PPBM system is to automatically recognize when baggage has been placed on an aircraft without an associated passenger. [Ref. 29]

# III. COMMERCIAL AND MILITARY USES OF AIT

## A. REVERSING LOGISTICAL ROLES

Logistics today is no longer thought of solely as a military term. In the battle of the business world, as in most military campaigns, the "victor" usually has the superior logistics network - the ability to efficiently and quickly move troops ( or product), supplies and equipment. Were as in the past, commercial industries adopted technologies and practices of the military, today the reverse is rapidly becoming a reality.

Despite undeniable differences between military and private sector logistics, similar objectives and constraints also exist. The best civilian firms have already faced and overcome many of these common challenges by combining technology with organizational adjustment. Additionally, competition in commercial industry has ensured that only the most effective systems have prospered. Therefore, as a result, military logisticians can learn valuable lessons from private industry.

Various private-sector companies have found that using AIT to capture logistics information, particularly when coupled with redesigned business processes, has helped improve their visibility over the status and location of critical assets. Striving to build upon that success, several DoD components are examining the use of AIT devices to improve their procedures for capturing similar information.

This chapter focuses on applications of the AIT technologies presented in the previous chapter. First, commercial use of individual technologies will be discussed, followed by how the military has adapted the technology for its own usage. The chapter

does not, however, present every use of each technology, but provides a broad overview of the most recent and emerging AIT applications in both private-sector and military organizations.

## B. COMMERCIAL USE OF AIT

### 1. 2-D Bar Codes

As previously mentioned, unlike conventional linear bar codes which essentially string data along a horizontal axis, two-dimensional codes use both the vertical and horizontal axis to encode data. As a result, hundreds of characters can fit into the space occupied by 30 characters on a linear bar code. [Ref. 10: p. 75]

With such promising data storage capability, it's not surprising that carriers and shippers have begun experimenting with 2-D technology. They've found that the high-capacity 2-D codes obviate the need to supplement their bar codes with a data-storage computer containing "look-up" information. Shipping data can be stamped on a container, thereby becoming a portable data file that travels with the item. This portability offers many advantages in distribution. So much so, that industry observers speculate that 2-D code may even someday supplant electronic data transmissions for some purposes. [Ref. 10: p. 75]

#### *a. Some 2-D Uses and Users*

The number of uses for 2-D code continues to grow. The following paragraphs describe how some major carriers and shippers are beginning to exploit the technology's large data storage capacity.

United Parcel Service is using its MaxiCode symbology for tracking and sorting packages at its Grand Rapids Michigan and Chicago area consolidation hubs. A MaxiCode label containing trailer, postal code, and control information is affixed to the tops of packages as they are unloaded from a trailer. The label then enables packages to be diverted to the proper lanes. [Ref. 10: p. 77]

Rival carrier Roadway Package System, Inc., (RPS) has also begun its own 2-D campaign. Roadway combined the linear Code 128 symbology with 2-D code PDF 417 into a design it calls "MultiCode." RPS will use the linear component for sortation purposes and the PDF 417 will be available to encode purchase-order number, consignee address, invoice number, and shipment-ID number. RPS feels that MultiCode will allow shippers to decide exactly what information they want delivered with their package. [Ref. 10: p. 77]

Two major motor carriers, Watkins Motors Lines of Lakeland, Fl., and Consolidated Freightways in Palo Alto, Ca., are working together to test PDF 417's effectiveness for carrying bill-of-lading information. The bill-of -lading has an area reserved for the PDF 417 symbol which, when scanned at the terminal, inputs the information into the billing system. The carriers hope that the use of 2-D symbols will expedite error-free transfer of information among the shipper, carrier, and consignee. [Ref. 10: p. 77]

Along with the various carriers, shippers are now looking at ways to take advantage of 2-D technology. WalMart uses 2-D codes to replace the advance shipment notice it formally sent electronically. The notice would let the consignee know what

freight to expect before it arrived at the dock. When a shipment moved only a short distance, however, the freight often showed up before the advance notice. Two-dimensional codes have eliminated the problem. A 2-D symbol that encodes the packing list arrives with the freight. In cooperation with its vendors, WalMart is also using 2-D codes for pack verification. Cartons arrive at the dock with a 2-D label with information on all the contents. [Ref. 10: p. 78]

### 2. Radio Frequency Data Communication / Identification (RFDC/ID)

A significant part of the information revolution has been the change in where, as well as how, information is entered into a data collection system. This change is especially evident in the growth of radio frequency data communications and identification (RFDC/ID) systems. Hand-in-hand with the proliferation of RFDC/ID has been an increased diversity in applications for the technology. The subsections below present but a small sampling of how RFDC/ID is being used in the commercial sector.

#### *a. Work in Process*

If an item has an RFID tag attached, it can be tracked throughout the manufacturing process. Work-in-process reports can identify more accurately the location and status of items because the data will be available instantaneously if reader locations are on-line. Improved work flow results when accurate times are recorded to reflect when an item enters and exits a work stage.

Conveyors equipped with readers can alert an operator to the arrival of new items and prompt the operator as to what function or process needs to be performed.

RFID tags can be read "on the fly" with out the necessity of stopping the item. Manual record keeping can be eliminated and process flow improved.

Hitachi Cable of Indiana (HCI) provides of an example of how RFID improves material flow. Trolleys with RFID tags carry HCI's work-in-process throughout the building. A network of RFID readers records the movement of each trolley as it travels between production processes. The network then feeds data into a portable computer with a touch screen, allowing production employees to schedule production on the rail system [Ref. 30]. Michael Hardy, president of Control Dynamics, the company which designed HCI's trolley system, said:

> Without the RFID solution we were faced with using stationary bar code scanners to identify where the trolleys were on the rail. We found (the scanners) to be more expensive, less reliable, and in need of more calibration and set up than the RFID system. Radio frequency identification was the only way to go for this application. [Ref. 30]

#### *b. Inventory Control*

Many warehouses are benefitting from the use of RFID in tracking and managing inventory. Individual items or entire pallets of items can be easily tracked. A forklift equipped with a reader can instantly identify the correct pallet for loading. Upon exiting or entering an area equipped with a reader an inventory list can be immediately updated to reflect the arrival or shipment of goods.

Because RFID tags can be hidden inside an object, the tag is less likely to be accidentally removed or damaged. A conveyor equipped with a reader can automatically update inventory lists when an item passes by. Manual labor to position and read the tag is unnecessary, therefore saving time and money. Additionally, many

accounting firms recognize the power of RFID to provide accurate inventories and are relaxing or removing cycle counting requirements, thereby providing companies major time and labor savings. [Ref. 31]

### c. *Access Control*

Proximity RFID cards and readers are perhaps the fastest growing segment of the access control market. Proximity cards/badges are issued to employees or visitors and readers are placed at entry doors, parking lot entrances, and internal locations where access needs to be controlled. When a badge passes near a reader, the door will unlock if the person is authorized to enter.

Access to particular areas can be limited to certain employees during certain hours. Such systems would also allow you to change access “permissions” during vacations and holidays. Additionally, visitors can be issued badges that only allow access to certain areas the day of the visit.

Records of entry and exit times for each person are kept for comprehensive audit trails, time and attendance systems, or for billing, such as in parking areas. Certain access systems can also determine if a specific person is in the building so messages or calls can be relayed to him or her. Reports can be generated that list all activity at a specific location, during a period of time or the activity of a certain person.

RFID access control is also emerging in the health care industry. Patients can be tracked in hospitals or nursing homes. Systems can be used for "wanderer control" in situations where elderly patients or patients with Alzheimer's might wander off. The systems can deny access to exit doors and notify the staff that a patient tried to exit.

RF Technologies of Brookfield, WI manufactures an infant/child security system called Code Alert. A device which attaches to a child's leg or arm sets off alarms if the infant is taken without permission from a hospital's maternity ward or a new mother's room. Unlike traditional monitoring systems, alarms will also sound if someone attempts to cut off the Code Alert device. In the most sophisticated systems, a triggered alarm also locks doors, deactivates elevators and essentially traps the potential kidnapper. [Ref. 32]

#### *d. Service Industries*

The benefits of RFID are not limited to production processes or access control. Service providers are also learning of the added value that the technology can provide to their businesses and their customers. The textile rental and car repair service industries provide two examples.

RFID is ideally suited for use in the harsh conditions of the textile rental industry. RFID tags are easily attached to garments, floor mats and linens. The rental companies use RFID to track their products during the laundry process and during route pickup and delivery. An RFID system allows the company to better service its customers by insuring the same garments, mats and linens are returned to the customer each week. Billing errors are minimized through more accurate records of items picked up and delivered to each customer. By tracking the number of washings, and repair rates of garments, the textile rental company can better choose from different suppliers. Better records of what comes in and goes out of the laundry each day helps the company control inventory shrinkage and manage resources. An RFID automated tracking system also reduces paperwork. [Ref. 33]

Using RFID in an automatic sorting system allows the rental company to sort hangered garments without costly manual labor. The system can use the tag in the garment or a tag attached to the hanger to identify the garment for sorting. Speed and accuracy of route makeup is significantly improved, saving on labor costs and reducing errors. [Ref. 33]

Radio frequency technology is also providing a better method of diagnosing automobile mechanical problems and enabling more efficient repairs. A system called SuperAdvisor, by Fujitsu Personal Systems, is the first wireless mobile service program available to automobile dealers and others in the car repair business. [Ref. 34]

Traditionally service advisors complete a repair order by hand and then enter the information into the garage's database. Previous attempts to automate this procedure often required customers to stand in line in front of a stationary terminal, waiting their turn to describe their vehicles problems. SuperAdvisor offers a comprehensive service program designed to improve customer relations, make service proactive and ensure compliance with auto manufacturers' policies and procedures. With the wireless capability, the service advisor has the mobility to inspect the car along with the customer.

The SuperAdvisor system uses a pen computer which gives the service advisor a level of mobility even a laptop computer could not provide. A stylus is used by the service advisor to navigate through comprehensive diagnostic menus. Wireless communication to the host system gives the advisor access to vital data, such as cost of parts and labor, and eliminates the need for redundant data entry. The service writer can

also check the vehicles service history on the facility's database and give the customer an opportunity to purchase other maintenance and repair services. After the service order is written, the customer signs on screen to authorize the repair. The order is then transmitted to the file server, printed for the customer and automatically entered into the main computer. [Ref. 34]

### 3. Contact Memory

Contact memory tags are advantageous for applications that require frequent updates of changes to stored data, or remote access to specific, actionable data, e.g., instructions or directions.

SwissAir has used the technology in combination with bar code scanning to improve cargo tracking. Bar code labels are applied to its air freight and each item is scanned as it is packed into the larger crate that will be loaded onto the plane. The bar code scanner is interfaced to a hand-held data collection terminal that also has a contact memory read/write unit interface. After the crate is fully loaded, the scanned data is downloaded from the hand-held terminal to a tag on the outside of the crate. Workers who unload the crate can get a complete listing of the contents by reading the tag with another portable device, eliminating the need to scan each item. [Ref. 35]

Several value-added resellers have developed guard tour systems that utilize contact memory tags. Tags are placed at specific locations and/or on objects that security guards are supposed to check on their rounds. The guard carries a hand-held read/write device and touches each item on the tour. The date and time of the guard's visit is written to the tag, which stores all transactions. Additionally, the read/write device can be

programmed to direct the guard to the next location or to perform a specific task (e.g., unlock a certain entrance at 6 a.m.). Nuclear power facilities are testing contact memory tags as a way to improve inspection accuracy and data recording for its hourly safety inspections, and the U.S. Postal Service has tested a similar system to record when mail is collected from public mailboxes. [Ref. 35]

Another use for contact memory technology is in the area of asset management. G.D. Searle, a leading pharmaceutical company, has implemented an automated asset management system based on contact memory technology to track as many as 20,000 pieces of equipment. The system uses Dallas Semiconductor's iButton contact memory device and an Omniwand contact memory reader manufactured by Videx. [Ref. 36]

The iButton, which can hold between 4k and 64k of information in either read-only or read/write formats, stores serial numbers, warranty information, calibration specs, repair and service history, and user instructions. The information can be both read and updated by the Omniwand, which can also scan bar codes. At the end of data collection, the updated data can be uploaded to a host system using the reader's internal PC card. [Ref. 36]

## C. AIT USAGE IN THE MILITARY

Post-conflict studies of every contingency from Vietnam to Haiti have routinely identified the need for better visibility over the movement and location of military equipment and supplies. One of the major obstacles to obtaining visibility over military shipments is the difficulty of capturing accurate and timely documentation. Several DoD

components are striving to overcome that obstacle by examining the use of various AIT devices. [Ref. 8: p. iii]

The value of AIT to Defense transportation is its ability to provide accurate information on the location and content of spare parts shipments, consumable items, subsistence, ammunition, unit equipment, and personal property at various nodes throughout the Defense Transportation System (DTS). Shipments could be tagged with bar codes, magnetic stripes, smart cards, optical laser cards, or RFID tags. The information on each tag could range from just a commercial container number to details on every item within a container.

However, although many private-sector companies are well on their way to integrating AIT into their business processes, DoD's efforts are in the early stages, except for the use of bar codes. The Defense Logistics Agency (DLA) and the individual services have used bar codes to help manage their supply depot operations for many years; DoD's unit deployment procedures have also used bar codes with varying success for more than 10 years. In addition, DLA is fielding a laser card AIT system for shipments originating at its depots, while the Army has purchased more than 10,000 RF-type AIT devices, examined various tagging scenarios, and conducted demonstration tests in Haiti and Somalia. [Ref. 8: p. iv]

The following sections will further discuss military AIT initiatives; not only in transportation, but other logistical areas as well.

### 1. 2-D Bar Codes

Although bar coding has been used in military applications for several years, DoD is now starting to explore uses for the expanded data capacity of 2-D technology.

The U.S. Army's project manager for ammunition logistics tested PDF-417 and Datamatrix codes. It was recommended that the Army use PDF-417 when there is a need for enhanced bar-code applications or forms automation. Datamatrix was recommended for use because of its capability to read from any angle, tolerate low contrast between the code and substrate, and nonreliance on precise edge detection [Ref. 8: p. B5]. On 6 July 1995, a Deputy Under Secretary of Defense (Logistics) memorandum designated PDF-417 as DoD's standard two-dimensional bar code symbology for defense logistics applications [Ref. 37].

However, PDF-417's use has not been limited to "mainline" logistical functions. The symbology has also been selected by DoD's Office of Personnel and Readiness as the 2-D symbology standard for the automated military identification card. One side of the credit card-sized ID carries the individual's digitized photograph, name, branch of service and social security number. On the reverse are listed the person's Geneva Convention personnel category, date of birth, height, weight, hair and eye color and blood type, a Code 39 linear bar code as well as a PDF-417 symbol that encodes not only all of the printed data but also the photograph. [Ref. 37]

The new card is created on blank stock with a commercial computer program, laser printer and digital camera. Pertinent information is printed on the card and encoded in the PDF-417 symbol, which can be decoded by conventional means and updated.

Eliminated are manual, error-prone rekeying, the use of preprinted cards, and the cost of film. [Ref. 37]

### 2. Smart Cards

During the Gulf War, the military experienced delays in troop deployments because personnel records (e.g., training completed, immunizations, etc.) were not up-to-date and readily available. The lessons of this experience led to the creation of the Multi-Technology Automated Reader Card (MARC). [Ref. 38]

The MARC utilizes integrated circuit chip, bar code, and magnetic stripe technology to produce a utility card capable of satisfying multiple functional requirements within the DoD for a portable, updatable data carrier. The combination of several AIT's on a device the size of a credit card gives the MARC the versatility to interface with a variety of technologies and systems. Personnel in the field will use the card to improve the speed and accuracy of transactions in such areas as medical care, mobilization for deployment, food service, transportation manifests and accountability of equipment. [Ref. 39: p. 6]

The 25th Infantry Division used the MARC to support a deployment of Division personnel to Haiti. The MARC was used to create and validate aircraft manifests rosters. In this test, the time required to produce manifest was reduced from over 4 hours down to 20 minutes and through MARC's technology the number of personnel involved in the manifesting process was reduced from 15 to 7. Functional applications in initial testing also included Field Medical Care. In these tests, significant time savings were experienced in the amount of time required to process casualties through use of the MARC to enter

condition and treatment data. The MARC replaces a paper medical form which was often lost or unreadable during the medical treatment and casualty evacuation process. [Ref. 39: p. 7]

### 3. Optical Laser Cards

Optical laser cards are part of the Defense Logistics Agency's Automated Manifest System (AMS). The cards store digital information about the contents of a container or multi-pack. This permits instant updating of an automated database, and the immediate retrieval of high-priority items.

AMS is intended to reduce cargo-handling time at ports as well as increasing the speed and accuracy of shipments. In initial tests, the system cut material processing time by 66 percent and boosted inventory accuracy rates to 99 percent. Prior to the system's implementation at two divisions at Ft. Hood, Texas, 14 soldiers doing material -receiving functions operated three eight-hour shifts daily. Now, with AMS, six soldiers do the job in one eight-hour shift. [Ref. 40: p. 27]

### 4. Radio Frequency Identification

By far the military's biggest use of RFID has been in the area of Total Asset Visibility (TAV) and Intransit Visibility (ITV). These initiatives emerged after Desert Shield/Desert Storm where containers without proper documentation were a big problem. Of the 40,000 containers sent to the Gulf, over half had to be opened to determine their contents. Necessary support equipment piled up in random fashion, and untangling it and getting it to the units that needed it seriously delayed military operations. The Army has

estimated that if an effective way of tracking the location and content of the cargo containers had existed at the time, DoD would have saved roughly $2 billion. [Ref. 41]

In answer to the problems described above, DoD has contracted Savi Technology of California to provide the U.S. military with RFID tracking systems to instantly identify large numbers of assets either in transit or in storage.

The Savi Asset Management and Transportation Management System is being used by all U.S. services: tracking equipment from Germany back to the U.S. for the Army; for troop and asset movements in Somalia, Haiti, South Korea, and Bosnia; as a real-time pre-programmed inventory of airfield ground support equipment for the navy; re-routing cargo while in transit for the Army; and locating jet engine parts inside a huge remanufacturing facility at Kelly AFB. [Ref. 42: p.25]

Using SaviTags (radio transponders), interrogators and Savi System Software, tagged military equipment can be monitored and tracked automatically without human intervention. The SaviTag, using radio signals or Global Positioning System (GPS) receivers, sends data to the interrogator which then relays this information to a central console. Items can then be located by an icon on a computer map. Another SaviTag, the SealTag, can also be placed on containers to provide information on their contents and final destination. [Ref. 42: p. 25]

# IV. AIT AND NAVAL LOGISTICS

## A. CHAPTER OVERVIEW

Our nation's military might is dependent upon the ability to decisively project power and maintain forward presence in foreign theaters vital to our national interest. But power and presence are much more than mere strike capability. They must include an ability to sustain the forces that will conduct and exploit these operations, even when conducted over prolonged periods and away from established supply lines. Thus, Naval power projection includes, and is made possible by, a dynamic logistics support system. This system, however, is much more than just material. It is a complex weave of systems within systems which encompasses planning, acquisition, maintenance, engineering support, training, transportation, facilities operations, and personnel support, which back-up naval forces day and night, in peace and war. [Ref. 1: p. ii]

In order to understand how AIT can be successfully integrated into that system, this chapter first provides an overview of Naval logistics. Section B outlines the nature of Naval logistics, section C discusses its fundamentals, and section D details the role information plays in support of logistics. The last two sections present examples of how AIT is currently being used within the context of the logistics system, along with some suggestions for future applications. Sections B through D and all figures are drawn from Naval Doctrine Publication 4, *Naval Logistics.* [Ref. 1]

## B. THE NATURE OF NAVAL LOGISTICS

A strong Naval team, capable of deterrence, war at sea and from the sea, and operations other than war, is essential to U.S. global leadership. Key to that strength is Naval logistics - the total integration of highly trained personnel within a complex network of technical support, facilities, transportation, material , and information links.

Joint Publication 1-02, Department of Defense Dictionary of Military and Associated Terms, defines logistics as "the science of planning and carrying out the movement and maintenance of forces." This science focuses on sustained operational readiness from day one - not just preparation for specific operations. Effective logistics support requires balancing the commander's requirements with the resources available. As Figure 1 shows, Naval logistics consists of *products* provided to the end user, such as equipment, supplies, facilities, services, and trained manpower; and *processes* used to provide and maintain those products, such as production, procurement, distribution, training, and maintenance.

In peace and war, the mission of Naval logistics is to provide and sustain our operational readiness by getting the right support to the right place at the right time. Thus, a major challenge to the Naval logistics system is the need to support any main warfare effort at its high tempo of combat while continuing to support all other efforts adequately. The system must anticipate the needs of many operating forces and integrate all functional areas of logistics in a responsive manner. This requires planners to ensure that the logistic pipeline, stretching from such sources as the continental U.S.

infrastructure to the forward-deployed end user, will consistently enable Naval commanders to exploit opportunities as they arise.

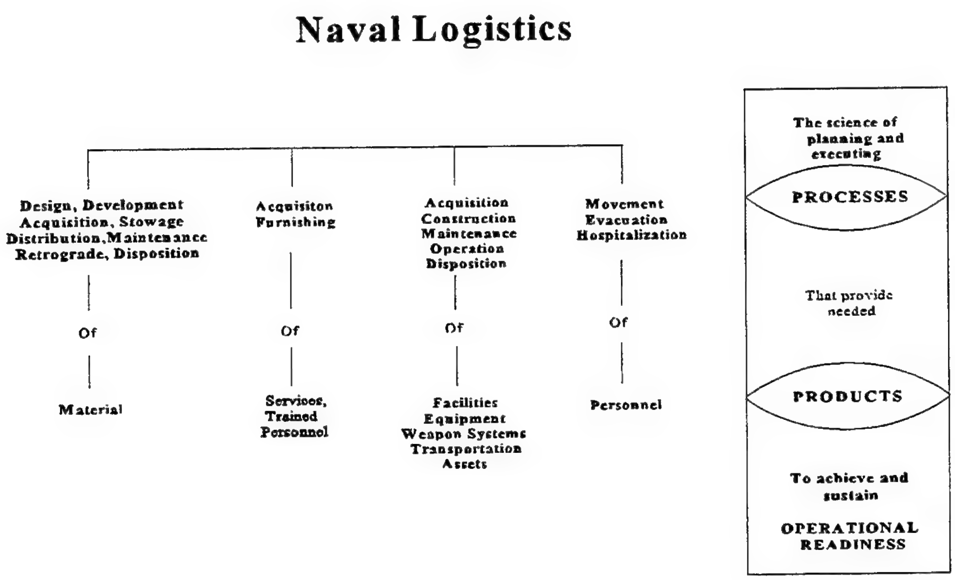


**Figure 1**

Current maneuver warfare philosophy encourages subordinate commanders to exercise initiative and gives them freedom to react to war's uncertain and fluid nature. Therefore, Naval logistic philosophy must complement this thinking and emphasize that its planners anticipate and respond quickly to operational needs.

## C. FUNDAMENTALS OF NAVAL LOGISTICS

Principles, functions, and elements of the logistic process are fundamental to the mission of supporting operational readiness. As shown in Figure 2, these fundamentals define the Naval logistic process - providing the proper products and right level of support to naval forces.

**The Naval Logistics Process**

**National Resources**

↓

**Process Elements**
Acquisition
Distribution
Sustainment
Disposition

↓

**Functional Areas**

| | |
|---|---|
| Supply | Maintenance |
| Transportation | Engineering |
| Health Services | Other Services |

↓

**Fulfill Fleet/Force**
**Operational Readiness Needs**

**Figure 2**

### 1. Principles of Logistics

Seven logistics principles serve as a guide for planning and conducting logistic support of Naval forces. Both the operational force commander, who needs to know the effective limits of the available logistic support, and the logistic planner, who has to ensure

that all the essential elements and full capacity of the logistic system are incorporated, must understand these principles.

*a. Responsiveness*

Providing the right support at the right time, at the right place is the most important principle of logistics. Ensuring that adequate logistic resources are responsive to operational needs should be the focus of logistics planning. Such planning requires clear guidance from the commander to his planners. Also, it requires clear communication between operational commanders and those who are responsible for providing logistics support. The operational commander's concept of operations must be thoroughly familiar to the supporting elements to ensure responsive, integrated support. Responsiveness is a product of logistic discipline. Commanders and logisticians who consistently overestimate their requirements in quantity and priority risk slowing the system's ability to respond.

*b. Simplicity*

Unnecessary complexity in preparing, planning and conducting logistics operations must be avoided. Providing logistic support never is simple, but the logistic plans that utilize the basic standard support systems usually have the best chance for success. Mission-oriented logistic support concepts and standardized procedures reduce confusion. The operational commander must simplify the logistic task by communicating clear priorities, and forecasting needs based on current and accurate usage data.

*c. Flexibility*

Logistics must be flexible enough to support changing missions, evolving concepts of operation, and the dynamic situations that characterize naval operations. A thorough understanding of the commander's intent enables logistic planners to support the fluid requirements of Naval forces. In striving for flexibility, the logistic commander considers such factors as alternative planning, anticipation, the use of reserve assets, and redundancy.

*d. Economy*

Mission accomplishment requires the economical use of logistic support resources. Logistic assets are allocated on the basis of availability and the commander's objectives. Effective employment further requires the operational commander to decide which resources must be committed immediately and which should be kept in reserve. Additionally, the commander may need to allocate limited resources to support conflicting and multiple requirements. Prudent use of limited logistic resources ensures that support is available where and when it is most needed. Without economy, operational flexibility becomes compromised.

*e. Attainability*

Risk is defined as the difference between the commander's desired level of support and the absolute minimum needed to satisfy mission requirements. The commander must determine the minimum essential requirements and ensure that adequate logistic support levels have been attained before initiating combat operations. In some cases time will permit building up support levels beyond minimum essential requirements.

During Operation Desert Shield, for example, the coalition retained the operational initiative and delayed the commencement of combat operations until a six-month supply of material was in theater and available to the operating forces. In this case, the commander was able to exceed the absolute minimum level needed to satisfy mission requirements.

#### *f. Sustainability*

Sustaining the logistic needs of committed forces in a campaign of uncertain duration is the greatest challenge to the logistician. Every means must be taken to maintain minimum essential material levels at all times. This requires effective support planning that incorporates economy, responsiveness, and flexibility. Sustainability also influences the ability to maintain and protect the ships and aircraft that move materiel to and from the operational theater.

#### *g. Survivability*

Logistic support units and installations, lines of communications, transportation nodes, and industrial centers are high-value targets that must be protected by both passive and active measures. Dispersion of installations and material is one element that may also be considered in a logistic defense plan. Easier management of resources might favor centralized logistic locations, but the survivability of logistic support may require decentralized locations. The dispersion of reserve stocks, development of alternative sources of supply, and phasing of logistic support all contribute to survivability. Alternative logistic sites and transportation networks should also be considered. Continued survivability requires that logistic operations not be dependent on a single source or mode of support.

All seven logistics principles seldom have equal influence; usually, only one or two dominate in a specific situation. At times the principles may seem to make conflicting demands, depending on the situation. For example, a need for absolute responsiveness may require actions that are not economical. As such conflicts illustrate, the principles of logistics are meant as a guide for planning support operations, not a checklist.

### 2. Functional Areas of Naval Logistics

As previously mentioned, Naval logistics is much more than the movement of material from one location to another. The most successful logistics operations consider the application of each of the aforementioned principles across six broad functional areas of logistic support. These functions include the following: supply, maintenance, transportation, engineering, health services, and other services.

#### *a. Supply*

The supply function includes design, procurement, contracting, receipt, storage, inventory control, and issuance of end items, repairable and consumable material, and eventual retrograde or disposal. The supply system must equip and sustain operating forces from predeployment through combat operations and subsequent redeployment.

#### *b. Maintenance*

This functional area includes all the actions necessary to preserve, repair, and ensure continued operation and effectiveness of weapon systems and components. It also includes the policy, organization, and issues related to the maintenance of equipment, afloat and ashore; development of maintenance strategies; standards of performance for

both preventative and corrective maintenance; technical engineering support; and battle-damage repair. The collection and analysis of materiel maintenance data supports the procurement and acquisition process.

### c. *Transportation*

In its most basic definition, this functional area involves the movement of units, personnel equipment, and supplies from the point of origin to final destination. At aerial and sea ports of debarkation, other responsibilities of transportation support include off-load, operational control of the ports, and management of the throughput. The theater reception and intra theater movement of personnel and equipment, medical evacuation, and retrograde of material are also part of the transportation function.

### d. *Engineering*

Construction, damage repair, combat engineering, and maintenance of facilities are all included under this broad functional area. Specialized units or technically trained personnel provide combat and civil engineering support. This could include: breaching and emplacing obstacles, maintaining lines of communication, constructing forward arming and refueling points, upgrading roadway systems, developing aviation support facilities, managing environmental matters, maintaining utilities, and many other essential functions.

### e. *Health Services*

Health services are designed to preserve, promote, and improve the health of Naval personnel , as well as their families. They provide medical and dental materiel, blood and blood products, and facilities and services in both combat and non-combat

environments. These services include providing emergency and routine health care to all personnel; advising commanders on the state of health, sanitation and medical readiness of deploying forces on a continual basis; maintaining health and dental records; keeping a current mass casualty plan; training personnel in basic and advanced first aid; maintaining medical intelligence information files; implementing preventive-medicine measures; and ensuring combat readiness of health care personnel assigned to various wartime platforms through continuous training.

#### *f. Other services*

This function includes all aspects of personnel support, quality of life, and morale issues that are essential to sustained combat effectiveness. Adequate, well-orchestrated services directly contribute to high morale and the combat effectiveness of forces. The function builds operational readiness through direct personal support. This area includes: administration, billeting, disbursing, exchange services, food services, legal services, mortuary services, postal services, religious services, and morale, welfare and recreation.

Logistics is much more than the amalgamation of its functional areas. Although all six areas must exist to enable a ship, battalion or other unit to perform its assigned missions successfully, each area must be properly combined and integrated into the command's planning and operations to provide the needed flexibility and adaptability.

### 3. Elements of the Logistics Process

Within each of the functional areas, four elements of the logistics process - acquisition, distribution, sustainment, and disposition - play important roles in recasting

national resources into the products and services needed to support operational readiness. Figure 3 illustrates how together these elements constitute the overall logistic process.

**Elements of the Logistics Process**

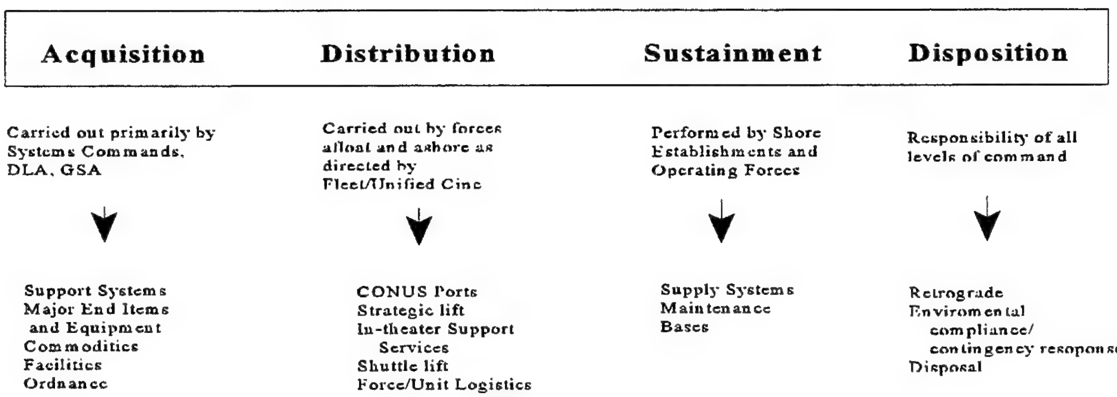


**Figure 3**

### *a. Acquisition*

The acquisition of weapons, support systems, end items, commodities, facilities, and ordnance is the process that provides new or improved logistic support over the long term, through formal planning, programming and budgeting. Investment in logistic support resources provides the basic building blocks of operational readiness and sustainability.

### *b. Distribution*

This is the process in which logistic support is allocated and delivered to maximize combat effectiveness. The methods used to get material, support services, and personnel to the operational commander depend upon what is being moved, its origin and destination, the lift assets available, and the urgency assigned. Transportation capability

can easily become the focus of distribution, but that is only one aspect. Distribution also involves overall management, inventory control, and the integration of logistic information support.

*c. Sustainment*

Proper sustainment capability allows Naval forces to remain on station as long as needed without interruption. Consequently, an early action taken in crisis response is prompt reinforcement of the Naval task force's logistics support pipeline. Continuous support by that pipeline is particularly critical during the initial stages of a crisis, to support potential long-term operations.

*d. Disposition*

This is the process that provides for the return of excess or not fully capable material for repair, redistribution, or salvage. The handling, stowage, retrograde, and disposal of material and resources must be a logistic consideration at all levels. Disposition is a matter of fiscal and environmental responsibility, as well as a matter of security when dealing with classified materiel.

A primary consideration is adherence to environmental protection laws, local through international. Avoiding adverse environmental impact requires responsible and conscientious action at all levels of command. Noise, air and water pollution; waste disposal; hazardous-material stowage; and disposal of shipboard hazardous waste are only a few areas of concern. Such considerations impact day-to-day Naval operations, the way training areas are used during exercises, and even peacetime conduct in ports around the world.

Principles, functional areas, and elements of the logistics process are the building blocks upon which logistics forces and support are planned and organized. Logistics principles provide the framework for arranging logistic support, in order to enhance the commander's probability of success even in the presence of unforeseen difficulties. The principles, functional areas and elements of the logistics process are interrelated and must be considered corporately in planning the logistics support component of naval operations.

## D. NAVAL LOGISTICS INFORMATION SUPPORT

Providing logistics support is a process of resource prioritization, allocation, distribution, and management. Locating and moving logistic support in a way that gets the right material, personnel, and services to the right users on time requires reliable logistic information support. Such support provides vital data before, during and after the planning process. It allows the commander to disseminate his logistic plan and enables him to coordinate and direct the distribution of logistics support during the plan's execution.

### 1. Interface with the Planning Process

Logistic support information systems are essential tools that assist the planner in:

- Translating plans and command decisions into the physical distribution of support resources
- Monitoring to ensure that the logistic system is responding to end-user requirements
- Informing the end user about the status of delivery.

Whatever the nature of the conflict or forces involved, logistics information will be a major factor. Logistics information support provides important planning data for such basic questions as: What do I have? What do I need? When will I get it? What will I do with it? The questions may seem simple, but the answers are spread among many dispersed areas of the logistic pipeline. This requires that planners have access to an integrated information network which will enable commanders and their staffs to plan, control and coordinate logistic support operations.

### 2. Logistics Command, Control, and Communications

Logistics information support assists the commander in aligning logistics support systems with the structure and employment of his combat forces. This unity of effort is best obtained through a single command authority, exercising command and control over combat forces and the support system that sustains them. Effective logistics command and control is characterized by:

- Timely and accurate receipt of requirements, expenditure information and shipping status
- Accurate inventory visibility, including material in transit
- Effective information management
- Flexible support that allows the reroute of cargo based on operational need
- Proper positioning with respect to transportation hubs and theaters of operation.

These characteristics require redundant and reliable communications that link users, providers, and commanders. Despite the apparent abundance of such modern communications technology as satellites, computers and fiber-optic transmission,

communications capacity is a limited resource. There will always be competition for communications, ashore and especially afloat. Therefore, communications for logistics support must be viewed as an operational requirement, not an administrative one. Logistics support connectivity is neither optional nor insignificant, in terms of its requirements for dedicated connectivity to update logistics requirements and resource availabilities.

### 3. Information Vulnerability and Security

New and evolving strategies and technology advances are improving decision-making processes. These advances help maintain preparation to perform wartime missions, as well as those missions that occur across the full range of power projection and forward presence. Technologies such as electronic mail and electronic data interchange, which use readily available commercial communication links and global computer networks, are becoming a routine part of the logistics planning environment. The collective volume of unclassified, discrete pieces of logistics data can reveal the classified intent and objectives of the force. Logistics planners and operational forces must recognize the importance, as well as the vulnerability, of logistics information and take the necessary steps to protect and back up these systems.

## E. CURRENT AIT APPLICATIONS IN NAVAL LOGISTICS

AIT has tremendous potential to effectively support Naval logistics in each functional area. As its capabilities continue to expand, AIT can also positively impact many of the principles of logistics (responsiveness, flexibility, simplicity, attainability, etc.).

This section will provide examples of how AIT is currently being applied in three of the six functional areas of Naval logistics: supply, maintenance, and transportation.

### 1. Mobile Detection Assessment Response System

The Mobile Detection Assessment Response System (MDARS) is an example of how AIT is supporting Naval Logistics' functional area of Supply. MDARS is a joint Army-Navy effort to develop and automate robotic security and inventory assessment capabilities for use in government storage facilities.

The system consists of a command and control console running the Multiple Robot Host Architecture (MRHA) controlling up to 32 interior and exterior robotic platforms. The Product Assessment System has been developed by the Naval Command Control and Ocean Surveillance Center (NCCOSC) as part of the MRHA to track the locations of selected items in warehouse inventory using interactive RF transponder tags placed on high-value or sensitive items. The tags, each with a unique identification number (Tag ID), and their physical locations are monitored by a Tag Reader Computer mounted on each robot. Information on Tag IDs and locations are uploaded from the remote platforms to a database server via the MRHA. [Ref. 43]

### 2. Aviation Maintenance and Returns

#### *a. Issue*

Managing the Naval aviation maintenance program, whether at the organizational level or depot level, is an administrative burden. AIT, however, is making passive data collection possible, where component identification is built into the product, giving it a unique footprint. Today, it is feasible that practically all repairable aviation

components could be scanned to determine its original manufacturer and its maintenance history. This will be vital since many aircraft repairables have the potential to be inducted into several organizations.

AIT increases the utility of existing aviation component assets through: 1) Life cycle marking and tracking of components by part number, serial number and manufacturer's code; 2) Configuration control and management of assets throughout the use-repair-store-issue-use cycle; 3) Asset visibility and control for high value components via a mechanized log book; and 4) A reduction in system inventory requirements.

#### *b. Background*

Aviation components are an integral part of the support equation in maintaining the readiness of our forces. These components range from entire assemblies (such as engines) down to micro miniature circuits used in other assemblies. The proper management and control of these assets is necessary to:

- Ensure the proper configuration for the weapon system it was designed to support,
- Minimize the number of assets brought into the logistics system,
- Properly identify the equipment configuration of a given end item,
- Ensure that life-limited components are replaced as necessary,
- Reduce the overall support costs of weapons systems,
- Respond to critical material requirements with the correctly configured asset, and
- Track assets through the repair cycle throughout their life/repair cycle.

### c. Discussion

The Naval Air Warfare Center at Patuxent River Maryland is sponsoring an AIT field study which is responsible for the design oversight, testing, and the monitoring of contact memory technology. Through the use of COTS contact memory AIT, these field studies have permitted the reading of maintenance history data via a scanner which can be linked to a Naval Aviation Logistics Command Management Information System (NALCOMIS) terminal. This linkage has the benefit of quick errorless downloading thereby allowing maintenance and supply actions such as asset tracking for example, to be initiated from the skin of the aircraft. The automation of asset identification and initial maintenance and supply actions will minimize fleet aviation maintenance data submission and material identification errors. These value added enhancements will significantly improve logistics response times, lower component turn around times and reduce asset inventory requirements.

### *d. Estimated Benefits*

In 1995 the Naval Aviation Maintenance Office (NAMO) responded to over 2,500 requests for Scheduled Removal Card (SRC) reconstruction data involving aviation related components. The estimated savings to Navy was approximately $70 million in unnecessary maintenance or premature disposal charges. Unfortunately, over 1,600 requests for lost log book reconstruction data could not be answered, with a potential cost of $32 million. The use of contact memory devices as paperless log books (vice SRC cards) will eradicate the lost log book problem. Preliminary Naval Air Systems Command (NAVAIRSYSCOM) estimates show that considerable savings are possible

from reductions in maintenance data entry errors and entry times at the squadron level by way of "AIT entry" of material failure and supply information. [Ref. 44]

The positive field test results and the apparent cost avoidance savings utilizing AIT at Patuxent River, inclined Naval leadership to recommend funding in the amount of $300,000 to be allocated for the continuance of concept trials, and the future assessments of the technologies' applicability throughout the Naval aviation maintenance and supply environments. [Ref. 44]

Not only will the customers benefit from contact memory technology, but the real time feedback provided to the maintenance organizations will offer better data on product reliability which will subsequently enhance the provisioning models of all Naval aircraft.

### 3. CINCLANTFLT AIT Project

In times of national crisis or during military contingencies, intransit visibility of SEAVAN contents have historically been poor. This matter is complicated in that freight is often pushed into the theater of operations faster than the container documentation has traditionally been able to catch up with it. Operations Desert Storm, Restore Democracy, and Sea Signal were classic examples of these shortcomings. During each of these operations, containers bottlenecked at the port of debarkation (POD) because the contents could not be identified for delivery. [Ref. 45: p. 8]

### *a. The Project's Beginning*

In June 1995, representatives of the Fleet and Industrial Supply (FISC) Center, Norfolk, Virginia, began initial conversations with Savi Technology, a California based manufacturer of RFID equipment and software. Working with initial funding of $250,000 from the United States Transportation Command's (USTRANSCOM) Mobility Enhancement Fund Program, FISC sought to install a Savi RFID system in hopes of improving the material flow process at their Ocean Terminal Container Freight Station (CFS). The realm of the initial project was only to monitor SEAVAN container movement within the CFS compound.

Due to world events, the project took on a whole new scope as the Cuban and Haitian refugee situation began to escalate in the Caribbean in the early 1990s. The Naval Base at Guantanamo Bay (GTMO), Cuba was designated as the Out Continental United States (OCONUS) processing facility for Operation Sea Signal migrant support and also for future migrant support contingencies. Commander in Chief, U. S. Atlantic Command (CINCUSACOM) subsequently tasked CINCLANTFLT to develop and provide all logistic support to 90,000 Naval, Joint Task Force and migrant personnel.

Asset visibility during any military contingency is of paramount importance in the day-to-day efficient and effective support of operations. Agencies, such as the Joint Chiefs of Staff (JCS) and Department of State need accurate information concerning high visibility operations. Up to date information flows will enable leaders at the highest levels to make better informed decisions. Hence, RFID technology was chosen by

CINCLANFLT, N4 as the projects primary AIT since it was reliable, available, and affordable.

#### *b. Project Sponsors*

Through contacts provided by Savi Technology, the Navy project had the assistance of transportation and computer specialists at the DoD Joint Defense Total Asset Visibility Office (JDTAV), the Army's Combined Arms Support Command (CASCOM) and the Defense Logistics Agency's (DLA) Operations Support Office. At each of the four In-Progress Review (IPR) meetings held between June 1995 and April 1996. Representatives from each of these activities, as well as technical experts from Savi, provided input on past lessons learned, better ways of utilizing equipment, and ways of standardizing data formats to make the tags readable between dissimilar RFID systems. Two outcomes of these of meetings were the adoption of the JDTAV standard tag format and the formulation the project's mission. Simply stated, the project's mission was to implement RFID and RFDC such that in-the-container visibility of all sustainment cargo consigned to activities located in GTMO was attained. An additional goal was to provide intransit visibility to the maximum extent possible through interface of the RF system with the Worldwide Port System (WPS), the Automated Manifest System (AMS), and other systems in place at the major shipping activities. [Ref. 45: p. 22]

#### *c. Concept of Operation*

Material consigned to GTMO is consolidated into SEAVAN containers primarily at four sites: FISC Norfolk Ocean Terminal; the Defense Distribution Depot

Jacksonville; the Navy Exchange Distribution Center Jacksonville; and the contracted commercial shipping company - Cuban Caribbean Shipping, Inc.

The specific ITV system developed under the CINCLANTFLT project to provide shipping documentation was named Service Wide Intermodal Freight Tracking System (SWIFT). SWIFT was designed as a graphical interface to be run on a standard 486 personal computer under Windows 95. Wherever possible, the system uses graphical representations of actual forms and documents for data entry, making it easier to learn and use. At GTMO, SWIFT was used to improve the process of discharging containers from ships and to update the on hand container inventories on the island.

When fully implemented, the system will be installed at each of the major suppliers for GTMO. As these sites load a SEAVAN container with freight destined for GTMO, they will write pertinent information about both the container and its contents to a data-rich RF tag. That tag which is normally affixed to the right rear door of the container, will accompany the shipments from point of origin to final destination.

#### *d. Project Equipment*

Savi was the prime contractor for the supply of RF equipment. Components included SealTags, Interrogators, RF Link Modules, Tag Docking Stations, and Hand Held Interrogators. Intermec was the supplier for the RFDC units. All Savi equipment training was provided at Savi headquarters in Mountain View, California. [Ref. 45: p. 12]

#### *e. Shortcomings*

- Each of the installed interrogators and RF Links had to be sent back to Savi to get resealed as a result of water leakage.

- A large majority of seal tags attached to refrigerated containers became inoperative. When the reefer box would begin to "sweat", the condensation penetrated the tag causing it to fail.

- The current method by which Savi Interrogators collect tags does not contain a data field which indicates whether the contents of each collected tag has been changed since any previous collection. This method makes it necessary to wake up all tags a second time which is redundant plus it reduces the tag's battery life.

- Even with frequent dialog with Intermec, the RFDC units could not be installed by the users. The equipment required installation by an experienced technician. [Ref. 45: pp. 33-41]

All of the above equipment shortcomings have been referred to the appropriate contractors. Maintaining an open dialogue between users and vendors is an important element in attaining the project's mission.

#### *f. Future of CINCLANTFLT Project*

A future enhancement to the CINCLANTFLT project will be the use of DLA's Optical Memory Card (OMC). Using RF tags and OMC technologies together provides a complimentary relationship. Collectively, they give complete "in the container visibility."

Combining this complete "in the container visibility" with different AIT instruments of capturing data as the container continues its movement through the transportation process, is the next step toward ITV. Additional AIT tools such as passive RF tags, active tags linked with the Global Positioning System, and RFDC collection

devices will provide the means of improving the flow of containerized material to the customer. These AIT tools could be used to update and maintain the location and status of each container on a real time basis. They would also allow updates to occur at the actual point of processing rather than from a remote documentation site. For example, as each container arrives or departs from a SWIFT fielded site, an ITV update on that container is captured via AIT and sent to a central database. Sites which are fielded with SWIFT and WPS would also automatically update USTRANSCOM's Global Transportation Network (GTN).

The SWIFT system, through the use of AIT, has provided unprecedented visibility to the resupply endeavors in GTMO. Container visibility in the Cuban resupply theater is now available to all managers of SEAVAN container operations, from the stevedores on the piers to the CINCs. [Ref. 45: pp. 3-4]

Many of DoD's logistical problems during the Gulf War could have been minimized or avoided if RFID technology and its data had been readily available and incorporated into systems similar to SWIFT and USTRANSCOM's GTN. The Navy, as evidenced by the CINCLANTFLT AIT project, has successfully expanded the use of RFID/AIT to provide supplementary ITV data when adequate communications capacity for logistics information exchanges were not available.

## F. POTENTIAL AIT APPLICATIONS IN NAVAL LOGISTICS

As AIT evolves and its Naval users become better educated, there will be more applications into which this technology can be introduced. In that regards, potential AIT applications, based in part on Naval operational experience, are summarized here. The

applications have been categorized under the functional area of Naval logistics each would support. No in depth discussion will be provided nor will the feasibility of any proposed application be evaluated. These lists merely serve to generate additional areas of interest in AIT and to illustrate the wide variety of applications to which the technology could be applied. These proposed applications have been forwarded and received by the Naval AIT executive agent - Naval Supply Systems Command, N4, with the intention of generating AIT uses not yet discussed by its newly organized (Summer 1996) AIT working group.

### 1. Naval Supply

- Tracking/Inventory of Ammunition and Sonobouys
- Accountability of small arms
- Tag controlled Equipage on ships and/or plant equipment at Shore Activities
- Use tags to improve inventory control for material with a shelf life
- Develop a Food Service Meal Pass (combine it with other cards, i.e., I.D., medical, dental, etc.)
- Apply RF tags triwalls containing multi packs. One read of the tag would annotate all contents, thus expediting "Receipts in Process."
- Tag Damage Control equipment onboard ships
- Attach tags containing Material Safety Data Sheet (MSDS) information onto incoming HAZMAT. MSDSs are required to be maintained onboard and to be made available to any user of the HAZMAT product.
- Documentation data of offloaded HAZMAT could be contained on tags. Positive identification of HAZMAT should offer life cycle tracking which is especially important to receiving activities. These activities (e.g., PWC Norfolk) have an assigned EPA generation number which necessitates tracking the HAZMAT through the waste stream in case discrepancies arise.

- Tag Maintenance Assistance Modules (MAMS) to ease the burden of tracking these repairables

- Tag Q COSAL and/or Level 1 material. Tags could contain appropriate pedigree documentation.

- Tag all general purpose test equipment for ease of accountability

- Use bar codes for issuing and receiving Communication Security Material (CMS) and classified naval publications. Issues to users could be made using the dual purpose food service, I.D. card.

- During technical assist visits, field changes or modifications to installed shipboard equipment could be annotated on contact memory chips attached to equipment.

- Tag gas cylinders for accurate tracking of manufacturer, thereby facilitating the turn-in of expensive empty cylinders.

**2. Maintenance**

- Passive tags could be imbedded on Ammunition Handling Equipment. This aids in maintenance data documentation, e.g., date last weight-tested, etc.

- Public Works could use contact memory chips to document maintenance on vehicles. These chips could be interfaced with "keyed" gas pumps which would deactivate if maintenance was not accomplished on schedule.

- Place tags on aircraft tires to provide wear rate information

- Tags attached to air craft engines could contain all maintenance history thereby eliminating the need for handwritten logs

- Tag all repairables and high dollar value consumables e.g.,valves. This would provide total asset visibility. Additionally, tags could contain maintenance history, manufacturing data, and actual drawings. Tagging repairables throughout their repair cycle will identify areas that need improvement.

**3. Health Services**

- Tag all high dollar medical equipment and controlled medicinals

- Data contained in medical records could be placed on smart cards

- Dog tags that contain the service member's SSN, blood type, etc., could be used for all personnel who are in battle zones. Vital medical data could be ascertained by the corpsman even if the patient is unconscious

- Sensor tags could be placed on patients to monitor body temperature, pulse, etc., while en route to permanent medical facilities

### 4. Transportation

- Attaching RFID tags to high priority material will provide positive tracking for Supply Officers thereby reducing lost shipments and resultant duplication of orders.

### 5. Other Services

#### *a. Security*

- Tags for identification and tracking of military working dogs could be safely imbedded under their skin

- Tags or 2D bar code labels could be attached to I.D. cards to determine who and how many personnel are on liberty. This information is especially important if situations dictate getting underway earlier than planned.

- Military Police could have active tags placed on their vehicles and/or their person which would allow dispatchers to make better use of their forces.

- Tags, either placed on their person or on clothing, could be used to expedite identification in the entry and exit of refugees from humanitarian camps.

- For any ships that may process and transport evacuees, 2D bar codes could be placed on the badges that the evacuees would wear upon checking onboard the ship. Maintaining strict accountability when conducting Non-combatant Evacuee Operations (NEO) is crucial for mission success. Utilizing AIT would ease the administrative burden and improve the efficiency of evacuee in-processing.

#### *b. Miscellaneous*

- Tag high value MWR equipment

- Memory tags placed on shipped Privately Owned Vehicles (POVs) could contain all appropriate documentation.

- Place memory tags house hold good shipments. These could contain bill of ladding information, etc.
- Tagging all tools issued from "tool central" could be accomplished with a scan of the sailor or airman's multi-purpose smart card.
- Apply AIT devices in tracking and accounting for certified and registered mail
- Use real-time RFID tags via GPS to monitor high risk troops, such as Navy Seals, during special operations

## G. CHAPTER SUMMARY

The Naval logistics system exists to meet the operational needs of our forces and is linked directly to our ability to conduct continuous forward presence, peacetime engagement, deterrence operations, and timely crisis response. It provides for much more than simply the movement of material, however. Through the application of each logistic principle across the six functional areas, the logistics system provides and sustains our operational readiness by getting the right support to the right place at the right time.

A proper understanding of the complexities of logistics allows for innovative improvements and perhaps doctrinal changes. In that regards, this chapter has provided an overview of the Naval logistics system and demonstrated how AIT supports three of the six functional areas. The current applications of AIT have been successful and have shown that the technology has tremendous potential to further enhance logistics capabilities, such as through the applications and suggestions presented in the last section.

# V. CRITICAL ISSUES FOR AIT IMPLEMENTATION IN NAVAL LOGISTICS

## A. INTRODUCTION

Naval combat operations are being transformed in their philosophy, concepts, and doctrine. Accompanying this change must be a parallel revolution in the logistics support structure that upholds the fighting edge of the Navy. But what should the Navy's logistics system look like in the 21st century? Only one thing is clear. It will not look like it does today. Captain Jim Martin of the Naval Supply Systems Command has this vision of the future,

> We will transform today's infrastructure intensive system into a lean, process-driven system where a single action by the customer activates a global network of sources that delivers best value products and services. [Ref. 45: p.3]

In order to accomplish such a vision it is no longer enough to just manage the flow of goods. Logisticians must also become managers of information. The computer age has made this change inevitable by allowing AIT and management techniques such as "just-in-time" (JIT) to become the norm in some logistics circles. While a JIT concept of logistics may not be feasible for the Navy, and given the uncertainties of warfare, might not even be desirable, one certainty remains. Change is inevitable and necessary for Naval logistics.

It is clear that AIT cannot magically provide solutions to all future logistical problems, but the technologies do have the potential to effect strategic as well as operational change within Naval logistics. With the need for such change in mind, this chapter will address issues which are critical for implementation of AIT into the Navy's logistics system. First, a brief discussion of barriers preventing AIT's wide-spread usage is

provided. Next, individual issues which are key to AIT's successful integration are discussed. A more detailed review of acquisition challenges is also presented. Finally, a model for AIT implementation is offered.

## B. POTENTIAL BARRIERS TO AIT PROGRESS WITHIN NAVAL LOGISTICS

Although there have been several successful projects, the application of AIT in Naval logistics has been somewhat localized. This does not lend itself well to future logistics scenarios. For as joint and multinational service operations continue to occur, a coordinated logistics system increases in importance. Therefore any consideration of future AIT implementation must include interoperability with not only other U.S. forces but also the commercial sector and international allies.

The present situation of AIT varies widely across the services. Therefore, to set the present situation in context, it is worth looking at potential barriers to AIT progress within Naval logistics.

### 1. Current Shelf Stock

All three services still have large amounts of stock on their shelves which are not coded with some form of AIT. Turnover of old stock and implementation of any new system will force standardized coding, but the delays and costs associated with this may act as a significant brake to overall AIT implementation.

### 2. Incompatible Systems

All services have a variety of older AIT and manual systems in place which are not compatible, but which may be perfectly adequate for the tasks they do. The costs of changing to a single system may be hard to justify.

### 3. Different Requirements for each Service

With each of the services operating in different ways and dissimilar environments it is hard to find common ground for a standardized system. The Navy may have particular problems with implementing the system on ships at sea. However, such differences are becoming less problematic as shared logistics responsibilities emerge.

### 4. Dissonance with Commercial Systems

There is some dissonance within the military with implementing off the shelf commercial AIT technology. This is in part due to the lack of standards with most of the technologies that have come along since linear bar codes. The military is used to dealing with standards, and more importantly requires AIT standards so that individual systems will "talk" with each other across commands, service and even nationalities. As issues of outsourcing, off-the-shelf technology, and commercial partnerships emerge, it becomes increasingly important to standardize AIT with the commercial sector. The rapid turnover in generations of AIT technology also creates some unease. Furthermore, as the DoD is subjected to continued internal changes, anxiety is created and thus a new logistics system is sometimes seen as a change too far. Finally, some military logisticians cannot see the relevance of commercial practices to a purely military environment.

### 5. Technology Infatuation

Despite the hesitancy of some logisticians, on opposite effect can also occur which is equally detrimental. As awareness of the possibilities of AIT grows, through internal publicity and increased involvement with the private sector, some managers may want to

rapidly adopt the technology. There is a danger of initiatives going ahead which will compound the problem of incompatibility.

## C. SOME IMPLEMENTATION ISSUES

With a thorough understanding of the issues surrounding AIT implementation, any organization, specifically the Navy, will be better able to craft a dynamic and robust strategy. The issues addressed here are followed by recommended implicit strategies that should supply resolutions to these featured issues.

### 1. Control

There is no central agency that has full responsibility for unbiased consulting, reengineering, design, development, integration, migration, and fielding of DoD AITs.

#### *a. Discussion*

AIT, as with most all emerging technologies, is constantly changing. Each service has specific needs for the technology but there are many instances where the services have similar requirements. Unfortunately, duplication of AIT requirements occur which translate to inefficient utilization of funds.

#### *b. Recommendation*

OSD should direct an organization within the Defense Logistics Agency (DLA) such as DLA's System Design Center (DSDC) to act as a central manager for all military AIT programs. DSDC is DLA's central design activity and is an acknowledged leader in providing AIT systems to the DoD. DSDC has deployed hundreds of AIT systems in the area of contract administration, distribution, material management, subsistence commodity, reutilization, and support. In fact, DSDC has received several

DoD Corporate Information Management (CIM) migration initiatives for their AIT systems. [Ref. 46]

Another activity that could augment DSDC responsibilities is the Defense Advanced Research Project Agency (DARPA). DARPA's mission is:

> Develop imaginative, innovative and often high risk research ideas offering a significant technological impact that will go well beyond the normal evolutionary developmental approaches; and, to pursue these ideas from the demonstration of technical feasibility through the development of prototype systems. [Ref. 47]

Directing the establishment of a central activity would serve as a clearing house for emerging AITs and it should reduce redundant and parochial initiatives pursued by the various Services. Further responsibilities of this agency could include:

- Approving official for all AIT acquisitions over a pre-determined threshold;
- Sponsor annual AIT seminars that would address cogent issues, and provide an excellent forum for the cross fertilization of ideas from the users and invited vendors;
- Serve as the conduit between commercial AIT system integrators and the Services;
- Provide generic lesson plans on various AITs which include a description of the applicable technology as well as its strengths and weaknesses, such as presented in Chapter Two. These lesson plans could become part of each service's General Military Training (GMT); and
- Drafting of an extensive web site that would contain compilations of ongoing and past AIT programs and initiatives. Additionally, the web site could serve as a warehouse of AIT information such as access to research papers, lessons learned from AIT projects, and offer the option to allow all military and civilian users the capability to make suggestions online.

### 2. Education

Military AIT education is limited in scale and scope.

#### *a. Discussion*

Military personnel, especially those in leadership positions, need to be educated as to the general benefits of AIT in various application contexts, including an overview of the advantages and disadvantages of individual technologies. The faster organizations educate their people at all levels, the faster they'll get in-depth utilization of their AIT systems and make greater use of the data available. Education has to be vertical, from top management down and also horizontal across major functional disciplines of the organization. There also needs to be in depth education for the personnel who will be operating the AIT. [Ref. 48: p. A16]

Personnel who undergo the training will understand how AIT works and they can visualize how it may provide convenience, security, efficiency, and quality to their organization. They will also have the ability to accept or reject the use of this technology when they are offered the choice by the various vendors or system integrators [Ref. 2: p. 6-15] In summary, the goal of all training would be to establish AIT awareness across all functional areas of Naval logistics.

#### *b. Recommendation*

There needs to be AIT course curricula offered at the postgraduate institutions and service academies. The Naval Postgraduate School could be a hot bed for formalized and lab intensive AIT training. Educating field experienced officers from all

Services should provide a multitude of opportunities to match the technology with operational needs.

### 3. Technology Explosion

AIT is evolving at such a rapid rate it is exceptionally difficult for users to stay current on the latest developments and how to best incorporate and/or upgrade them once the technology has been procured.

#### *a. Discussion*

Since the technologies under AIT are relatively new and sometimes complex, there emerged a need for competent third party consultants. The commercial sector responded in development of System Integrators. An AIT systems integrator can be defined by what services they provide [Ref. 48: p. A14] For example, the Systems Resources Corporation (SRC) offers one stop shopping for information systems and support. It can provide technical personnel for temporary or staff augmentation for software development and maintenance projects, systems analysis, and operation and maintenance of customer computer facilities. SRC also utilizes multi-disciplinary teams and strategic inter-company relationships to provide technical solutions to a wide range of challenges. [Ref. 49]

This kind of self-description fulfills the company's obligation to accurately characterize its integration capabilities. With system integrators' capabilities well defined, the user will be able to employ integrator teams for large scale projects and to feel more confident in the selection of a systems integrator for a more focused undertaking. [Ref. 48: p. A14]

#### *b. Recommendation*

In a military setting, DSDC would be a logical choice as DoD's AIT system integrator. Since the organization has knowledge of the Services' operations and standards, it could function as AIT educator, systems analyst, and technical advisor.

### 4. Standards

The lack of AIT software and hardware standards have the potential to render the technology useless if and when there is a need to communicate with other AIT systems. This problem is compounded when the need arises to communicate not just within the particular Service, but also when communicating with other Services and Services belonging to NATO, as well as commercial suppliers.

#### *a. Discussion*

Standards are the solution to successful growth of any AIT. The rapid growth of bar codes, for example, was the result of several carefully considered symbology standards. However, these symbologies were smoothed out over a long period by various technical societies. [Ref. 50: p. 48]

The problem with the less mature AITs, such as RFID, is the abundance of manufacturers with many proprietary systems. Understandably, many companies would have to give up a share of the market in exchange for cross licensing of competing RFID systems. [Ref. 51: p. 23]

Advantages of standard software include portability and reduced training times. Portability supports reusability of software in that the same program can be used

on several different computers or for different applications. This can result in higher reliability and maintainability of software. [Ref. 52: p.248]

#### *b. Recommendation*

Wait for the companies to implement a standard for those AITs currently without one. Secondly, when procuring AIT through government contract, ensure the mandate for commercial-supplied AIT is based on non-government standards and commercial item descriptions to the maximum extent practical [Ref. 53: p. 3.3.1] Government standards have a history of being too rigid which often leads to higher acquisition and life cycle costs.

### 5. Advance of Private Sector AIT

While DoD purchases have declined, America's commercial markets have continued to expand. The rapid growth of the commercial industrial sector, driven by a commercial market flourishing quite independently of DoD, has reduced the once central role of defense spending as a driving force for innovation. In light of the above, how does the DoD derive the greatest military benefit from technologies available on the commercial market? [Ref. 54: p. 47]

#### *a. Discussion*

The commercial industry surpassed the DoD in R&D spending back in 1965. The disparity between the DoD and the commercial sector investment in R&D has been growing wider ever since. This difference means that increasingly more of this nation's technological momentum will be based on what's coming out of essentially commercial enterprises. [Ref. 55: p. 142]

Leveraging commercial technological advances to create military advantage is critical to ensuring that our equipment remains the most advanced in the world. A tighter relation with the commercial markets can shorten the cycle time for defense system development and reduce the cost of inserting technological improvements into DoD systems. The DoD cannot afford a fifteen year acquisition cycle time when the comparable commercial turnover is every three to four years. [Ref. 55: p. 143]

#### *b. Recommendation*

Implement Dual Use Technology in AIT defense procurements whenever feasible via a strategy that was documented in a February 1995 DoD report entitled *Dual Use Technology: A Defense Strategy for Affordable, Leading Edge Technology* [Ref. 55] The strategy contains three main pillars:

- Invest in dual use technologies critical to military applications;
- Integrate military and commercial production; and
- Insert commercial components into military systems.

The goal of such a strategy is designed to leverage off the commercial technology base without having the taxpayer make the entire source investment.

## D. ACQUISITION CHALLENGES

This thesis has stressed the need for interoperability among AIT systems. In that regards, it is envisioned that a combined military system will result. Therefore, addressing acquisition issues relating to that system will be key. As such, this section will provide an overview of three important aspects of the acquisition process: Research and Development (R&D) funding, Integrated Logistics Support (ILS), and system architecture.

A vital component of any system acquisition is R&D. In the context of a DoD AIT system, R&D will increase in importance as it becomes necessary for service specific systems to combine. Funding for R&D has a recent reform history that started in the mid 1980s under the Reagan administration. A brief overview of that reform effort is provided.

In July 1985, President Reagan established the Packard Commission on Defense Management to study the issues surrounding defense management and organizations. One recommendation stated that a high priority should be given to building and testing prototype systems and subsystems before proceeding with full-scale development. This early phase of Research and Development (R&D) should employ extensive informal competition and use streamlined procurement processes. It should demonstrate that the new technology under test can substantially improve military capability, and should as well provide a basis for making realistic cost estimates prior to a full scale development decision. Additionally, the commission recommended that DoD should make greater use of components, systems, and services available off-the-shelf. This increased emphasis on prototyping should allow for the concept "fly and know how much it costs before the buy". [Ref. 52]

The Packard Commission sparked major reforms in DoD acquisition. This section presents detailed insight on the constraints placed upon today's Program Managers (PMs) while emphasizing the implications for AIT acquistion. The word "constraints" should not be construed negatively. Rather, these mandates placed upon the PM ensure that taxpayers' dollars are fully utilized.

As U.S. revenues continue to decline in relation to the increase in mandatory spending programs, DoD will always have "a tight budget belt". How then does the Navy acquire the appropriate funding for AIT R&D? One solution afforded is the use of DoD sponsored programs such as the Small Business Innovative Research (SBIR) program. SBIR, along with the Small Business Transfer Technology (STTR) and Fast Track programs, fund early stage R&D projects at small technology companies. For example, Savi Technology, Inc. of Mountain View, California developed the first radio computer tag, the "Savi Tag" using a combination of Defense Department SBIR funding and private venture capital. Savi Tag was developed with just $2.5 million in SBIR funding and has become a central element in DoD's TAV effort [Ref. 57]. Also outlined in this section, is an overview of SBIR and its two sister programs. Familiarity with these programs should "open up" additional funding sources for the Navy.

Whether the reader is an AIT user, developer, or top line manager, understanding the acquisition process and alternative avenues for R&D funding, should enhance the probability of a successful AIT project.

#### 1. Funding

Available funding for AIT development, maintenance, and modernization is scarce. While the Navy and the other Services are being forced to keep up the pace in the quality of its equipment, the money available for military use has been cut drastically, and the current downward trend in funding is inevitable [Ref. 58: p. 2] as evidenced in the current defense budget out years. Pressures of this sort, however, may motivate improvements in the underlying processes that control DoD and should also provide the opportunity for innovation.

#### *a. AIT Development, Maintenance, and Modernization*

Much of DoD's recent progress in AIT has been driven primarily by the commercial industry. The technology has increased at an incredible speed and has rendered almost all electronics products obsolete in only a few years. Thus, to stay current DoD must renew its AIT equipment every few years with the latest in technology while at the same time retraining its personnel in operating the equipment.

The normal process of new technology development presents a dilemma: Users want to add new capability while modernizing their systems, but cannot be confident that budgets and schedules will be met. The idea is to create a development process that is organized around the government's need to improve the reliability of AIT and industry's ability to understand the relationship among possible new capabilities, production costs, and development time. [Ref. 58: p. 34]

Today the costs associated with maintaining an electronics system will increase significantly over the next several years as a result of the short lifetime of modern electronics and the greater design cost for the more complex integrated parts. Only small increases in system availability can be achieved by redesigning individual parts and subunits, so the decrease in availability brought about by cuts in support resources must be addressed at the system level. [Ref. 58: p. 66]

#### *b. Reasons for Government Funding of R&D*

There are two principal reasons for government funding of R&D. First, cutting edge technology development is often high risk. Government realizes that such research needs funding far earlier than the private sector typically provides (before working prototype phase). These programs accelerate and enable potentially important projects that industry otherwise wouldn't undertake because of the business risks involved

[Ref. 59: p.6]. A government grant allows executives to worry less about the products paying today's bills and more about tomorrow's "big hit."

Second, small technology companies are a profound source of invention. Principal Deputy Under Secretary of Defense for Acquisition and Technology stated at a National Manufacturing symposium in March 1996, "They generate a disproportionately large share of the technological innovations in the economy, including the most significant innovations."

c. ***Overview of DoD Sponsored Programs***

Funds are made available that finance early stage research and development (R&D) projects at small technology companies. These projects serve a DoD need and have commercial applications. The three existing sponsored programs are addressed in detail so as to provide the reader a more thorough understanding of how these funded programs could augment the Navy's R&D funds. Plus, there is heavy emphasis placed upon the Program Manager's responsibilities in the acquisition process. Sponsors and users of AIT require a thorough knowledge of this process since in many circumstances they will be held responsible for the AIT project's success. In-depth user knowledge of the various DoD sponsored programs and close liaison with the program manager (for major systems) will increase the chance for program success.

(1) The Small Business Innovation Research Program. DoD's Small Business Innovation Research (SBIR) program funds early stage R&D projects at small technology companies--projects which serve a DoD need and have the potential for commercialization in private sector and/or military markets. The program, funded at roughly $500 million in 1997 [Ref. 60] is part of a larger ($1 billion) federal SBIR program administered by ten federal agencies (Departments of Agriculture, Commerce,

Education, Energy, Health and Human Services, Transportation, EPA, NASA, National Science Foundation, and the Nuclear Regulatory Commission).

The purpose of DoD's SBIR and STTR (Small Business Technology Transfer) programs is to harness the innovative talents of our nation's small technology companies for U.S. military and economic strength. SBIR targets the entrepreneurial sector because that is where most innovation and innovators thrive. However, the risk and expense of conducting serious R&D efforts are often beyond the means of many small businesses. By reserving a specific percentage of federal R&D funds for small business, SBIR protects the small business and enables it to compete on the same level as larger businesses.

As part of its SBIR program, the DoD issues an SBIR solicitation twice a year, describing its R&D needs and inviting R&D proposals from small companies--firms organized for profit with 500 or fewer employees. Companies apply first for a six month phase I award of up to $100,000 to test the scientific, technical, and commercial merit and feasibility of the particular concept. No more than 33% of an award can be subcontracted. If phase I proves successful, the company may be invited to apply for a two-year phase II award of up to $750,000 to further develop the concept, usually to the prototype stage. No more than 50% of an award can be subcontracted. Proposals are judged competitively on the basis of scientific, technical, and commercial merit. Following completion of phase II, small companies are expected to obtain funding from the private sector and or non-SBIR government sources to develop the concept into a product for sale in private sector and or military markets. [Ref. 61]

(2) The Small Business Technology Transfer Program. In 1992, Congress established the Small Business Technology Transfer (STTR) pilot program. STTR is similar in structure to SBIR but funds cooperative R&D projects involving a

small business and a university, federally-funded R&D center, or nonprofit research institution. The purpose of STTR is to create, for the first time, an effective vehicle for moving ideas from our nation's research institutions to the market, where they can benefit both private sector and military customers. Research is to be conducted jointly by a small business concern and its partner. Not less than forty percent of the work must be performed by the small business concern and not less than thirty percent by the nonprofit research institution. [Ref. 62]

DoD's STTR program, funded at $30 million in FY 97, is part of a larger ($60 million) federal STTR program administered by five federal agencies. DoD issues one STTR research solicitation each year. [Ref. 63]

(3) SBIR and STTR Fast Track. As of October 1995, DoD's SBIR and STTR programs feature a new "Fast Track" for small companies that attract independent third-party investors who will match both phase II funding and interim funding (between phases I and II), in cash. The purpose of Fast Track is to significantly increase the SBIR program's success in converting SBIR research into successful new products in phase III. The third party investor can obtain a match of between $1 and $4 in DoD SBIR or STTR funds for every $1 that the investor puts into the project. Part of the proposal for funding includes submitting a business plan for commercializing the new technology after government funding ends. The applicants retain the patent rights to any inventions they develop.

DoD's processing of all Fast Track applications is reviewed by the Under Secretary of Defense for Acquisition and Technology, to ensure the policy's effective implementation. [Ref. 61]

#### d. *Feedback on the Programs*

"Money down the sewer," that's what Ronald Reagan's science adviser originally thought of a program called SBIR. Before SBIR was enacted in 1982, all of the federal agencies involved opposed it. The opponents were wrong. SBIR participants have done so well that even Reagan's adviser changed his mind and later testified in favor of extending the program. In 1988 the federal agency project officers told the Government Accounting Office (GAO) that on average SBIR projects were of higher quality than those performed by traditional government contractors such as large corporations or universities. SBIR researchers were found to be more creative, more skilled, more likely to use appropriate research models, and more effective in project management. And these projects were more likely to lead to invention and commercialization of new products. [Ref. 41]

Savi Technology, Inc. of Mountain View, California developed the first radio computer tag, the "Savi Tag" using a combination of government SBIR funding and private venture capital. Savi Tag was developed with just $2.5 million in SBIR funding and has become a central element in DoD's TAV effort. [Ref. 63]

The SBIR programs have received strong bipartisan support in both the Armed Services committees and several other committees of Congress. This support was based on results, endorsements from the National Academy of Science, and two highly favorable reviews from the GAO. [Ref. 58: p. 9]

#### e. *Commercial Off-the-Shelf / Dual Use Technologies*

For the last ten years in the Defense acquisition community, there has been great emphasis placed on obtaining the best technology that the commercial sector has to offer. The rules and regulations are many, although they have been recently streamlined, but they do increase the success rate of obtaining the right product at the right price, at the

right condition, and at the right time. Some of the requirements that have been placed upon the PMs are highlighted in the following discussion. These mandates put considerable constraints on the PMs but they have nonetheless provided positive program results.

DoD instruction 5000.2R (Mandatory Procedures for Major Defense Acquisition Programs and Major Automated Information System Acquisition Programs) states that market research and analysis shall be conducted to determine the availability and suitability of existing commercial and non-developmental items prior to the commencement of a developmental effort, during the development effort, and prior to the preparation of any product description. The PM shall define requirements in terms that provide vendors of Commercial Off the Shelf (COTS) technology an opportunity to bid on these requirements. The PM must also develop an acquisition strategy that encourages vendors to employ dual use technologies or commercial plants and supplies for defense-unique items, to the maximum extent practicable. Dual use technologies are defined as technologies with both military and civilian applications.

As per USC 644, the PM shall consider all prospective sources of supplies and/or services that can meet the user need. COTS shall be considered as the primary source of supply. The PM, through the use of Integrated Product Teams (IPTs), shall include in the consideration the national policies on contracting and subcontracting with small businesses.

#### *f. Recommendation for AIT Development, Maintainability, and Modernization During DoD Budget Cuts*

Horowitz recommends a four step method for development and acquisition of DoD electronic systems [Ref 57]:

Step 1- The government provides industry with data on the support resources (workers, spares, technical orders) for individual systems.

Step 2 - Members of the industry are invited to propose two phased modernization efforts (like the two phases of SBIR programs) for any systems they wish, at any time they wish.

Step 3 - Consistent with a prescribed budget, the government funds the best conceived efforts to the point of a production decision. Some systems may have more than one effort directed at their modernization.

Step 4 - The government makes the production decision based on price, quality, reliability, and the possible upgrades. During the lead time of production, the desired improvements can be developed for production consideration and installed later as field upgrades. [Ref. 58]

Such a program can ensure the dependability of the AIT infrastructure that supports the forces, while permitting financial reductions in logistics support. High system availability, however, cannot be achieved solely through keeping the concerned AITs operating efficiently; users of AIT need constant training through operational exercises. The funding for operational exercises or AIT prototypes should be continued despite budget cuts, even though these funds compete with maintenance funds.

#### *g. Recommendation for Acquiring R&D Funds for Major AIT Programs*

Executive Agents of Naval AIT should understand the purpose and mechanics of the SBIR/STTR and Fast Track programs. Further education on the programs can be obtained by contacting the SBIR/STTR program office.

Just as AIT has become more efficient and streamlined, government procurement procedures are also following suit. The next three issues are inherently related to Defense acquisition which is the only mechanism DoD uses to acquire its commercial goods and services.

### 2. Integrated Logistics Support

The complexity of today's AIT systems have made them more difficult and expensive to maintain. There needs to be a cost effective approach that integrates support into system design early in the systems acquisition process.

#### *a. Discussion*

The objective of Integrated Logistics Support (ILS) is the integration of logistics support within a system designed to meet user's readiness requirements and is supported by a well balanced and cost effective logistics package. Execution of a sound integrated logistics support program is essential to a systematic process of transforming a military need into an operational system. Research, planning, and understanding critical issues and risks inherent in the design and development of any new AIT system are required. [Ref. 64]

The average Operations and Maintenance (O&M) costs of defense systems have steadily risen to more than fifty percent of the systems total Life Cycle Cost (LCC). Knowing that the greatest amount of total LCC dollars are spent on O&M, which really equates to logistics support, and that the large percentage of total LCC is committed early at the front end of an acquisition program, necessitates the need for a credible ILS plan. [Ref. 53: p. 260-263]

Four ILS related terms and definitions below are essential to understanding the critical role ILS plays in the acquisition process.

- **ILS Elements** The principal elements of ILS include: Maintenance Planning; Manpower and Personnel; Supply Support; Support Equipment; Technical Data; Training and Training Support; Computer Resources Support; Facilities; Packing, Handling, Storage, and Transportation; and, Design Interface.

- **Integrated Logistics Support Plan (ILSP)** The ILSP is the government's formal planning document for logistics support. It is kept current through the program life and sets forth the plan for operational support, provides a detailed ILS program to fit with the overall program, provides decision-making bodies with necessary ILS information to make sound decisions in system development and production and provides the basis for ILS procurement packages/specifications, Requests for Proposals (RFPs), Statements of Work (SOW), source selection evaluation, terms and conditions, and Contract Data Requirement Lists (CDRLs).

- **Logistics Support Analysis (LSA)** The selective application of scientific and engineering efforts undertaken during the acquisition process, as part of the systems engineering process, to assist in: causing support considerations to influence design, defining support requirements that are related optimally to design and to each other; acquiring the required support; and providing required support during the operational phase at minimum cost.

- **Logistic Support Analysis Record (LSAR)** A formal tool that uses records and forms to document operations and maintenance requirements. It is the medium through which task results and support data are recorded to help develop and validate support capabilities and requirements. [Ref. 65]

An ILSP is one of the primary documents that support ILS planning. The LSAR is another document which supports the LSA. An ILSP and LSA are the vehicles for implementing ILS requirements during the acquisition process. Whether the program is large or small in scale, the ten ILS elements should be evaluated for their applicability to a program. For a ILS program to be effective, it must be periodically reviewed and updated if necessary. Changes, however, can be devastating since change often leads to higher costs. All changes must be evaluated for their impact on the ILS elements and other logistics processes involved in the ILS program.

#### *b. Recommendation*

Developing a sound ILSP and LSA should be viewed as a mandatory process which can more thoroughly examine the requirements for supporting cost effective AIT which is vital to our defense needs [Ref. 53: p. 270]. Additionally, all players in the acquisition process from the user to Congress need to understand that early ILS planning in the concept exploration and definition phase is critical in defining the future costs associated with the equipment's life cycle.

### 3. System Architecture

All too often the government and industry focus too narrowly on achieving the initial requirements for systems and give little thought to being able to adjust what the system may be required to do five years later, or to what happens as hardware may no longer be supportable or as advanced technology may become available for incorporation into the system.

#### *a. Discussion*

The definition of architecture is the design and interconnection of the main components of a hardware/software system [Ref. 65] Architecture design is the key to achieving the cost savings and operational flexibility inherent in AIT systems. If the system is properly structured, then hardware components can be added or upgraded without expensive changes to the rest of the system. A good architecture allows a system designed to counter one risk, to also address a different threat, through localized modifications to the software that change the operational potential of the system or allow it to operate with other systems.

#### *b. Recommendation*

Since contract requirements drive the entire development of a system, the surest way to ensure coherence to a sound architecture is to put architectural requirements in the system specifications [Ref. 58: p. 70]. Providing these specifications may require the aid of a systems integrator who should have a firm grasp on the technical jargon that is frequently included in contract specifications.

## E. AIT IMPLEMENTATION MODEL

Figure 4 is a model for AIT implementation within Naval logistics. At the center of the model is the goal of the Navy AIT effort, an integrated system. Supporting that goal are three areas which contain all the issues discussed in the preceding sections. It must be stressed that these issues are interrelated and if one area becomes weaker or stronger than the other two, the system will begin to deteriorate. Therefore, attention must be paid to address each area in a balanced manner.

The previous recommendations offered to deal with each issue are feasible. If successfully applied they should enable the Navy to realize a dynamic, versatile, and expandable AIT system which exhibits the best value attainable for the taxpayers' dollar. But more importantly it combines efficiency with effectiveness in order to provide support for today's Naval forces.

# AIT IMPLEMENTATION MODEL

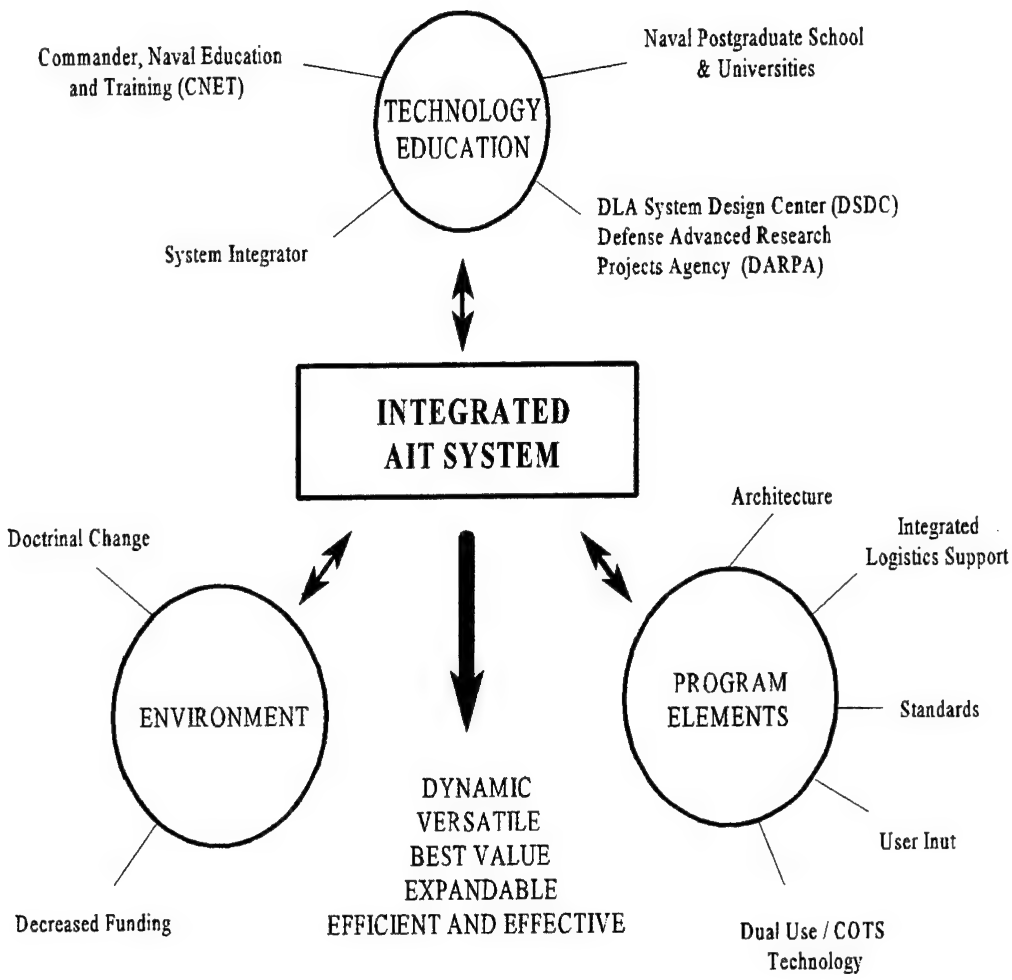


**Figure 4**

# VI. SUMMARY AND RECOMMENDATIONS

## A. SUMMARY

Responsive and timely logistics is what today's war-fighters need. In order to meet the logistics challenges associated with new operational concepts and doctrines, Naval logisticians must continue to refine and develop support systems which will exploit current technologies to their fullest potential. As such, every effort should be made to further incorporate AIT into the Navy's logistics system. Clearly, the technologies are powerful tools which offer many future possibilities in Naval support applications. They create improved material control, asset visibility, and efficiencies in overall management operations. While AIT cannot individually resolve all logistics challenges associated with the battlefields of the 21st century, the technologies can provide Navy logisticians and commanders information and capabilities that have previously not been available.

It has been the goal of this thesis to establish an awareness of AIT capabilities and show how the technologies can be integrated into all functional areas of Naval logistics. However, it must be remembered that the topics discussed in the preceding chapters relate to rapidly emerging technologies. Therefore, the applications and "solutions" that are offered must be seen as transitory steps that should enable the Navy to obtain the ultimate goal of an improved logistics system. To that end, since AIT technology is dynamic, the system adopted by the Navy may be significantly different from the technology presented in this thesis.

In summary, AIT is here to stay and its capabilities will only continue to grow. Although many issues associated with its implementation are complex, delay could be more costly than mistakes. Despite budgetary pressures which may argue against large-scale usage, a more appropriate view is not to ask, "How much does it cost?", but instead ask, "What is my application, and does AIT meet its requirements?" The opportunities for productivity improvement and cost reduction through AIT are limited only by imagination.

## B. AIT ISSUES AND RECOMMENDATIONS

Several issues are central to AIT's successful implementation and integration into the Naval logistics system and, more importantly, DoD's overall logistics network. These issues are summarized below and are followed by recommendations to address them.

### 1. Control

No central agency has full responsibility for all military AIT programs. Therefore, some duplication of AIT initiatives occurs across services. This translates into inefficient utilization of funds and resources.

Recommendation

The Defense Logistics Agency's System Design Center (DSDC) should serve as DoD's central activity for AIT oversight. This would remove any parochial management issues and further enhance AIT standardization throughout DoD. Responsibilities would include systems acquisition, education, commercial interface and applications research.

### 2. Education

In the military general knowledge of AIT capabilities is currently limited. Additionally, AIT is a rich and dynamic technology that requires constant and careful management attention in order to glean its full benefits. Therefore military personnel, especially decision-makers, need to understand the advantages and disadvantages associated with AIT technologies. The faster people at all levels become knowledgeable of AIT, the faster feedback for AIT applications and improvements can be provided. This also provides faster realization of AIT's efficiencies.

Recommendation

Education and input is vital to successful implementation of a Navy-wide and DoD-wide AIT system. As such, AIT course curricula needs to be offered at the Naval Postgraduate School, service academies, warfare specialty schools, Supply Corps school, appropriate enlisted technical schools, and general military training (GMT). Involving end users and field experienced officers from all services should provide a multitude of opportunities to match the technology with operational needs.

### 3. Technology Explosion

AIT technologies are evolving at such a rapid pace that it is becoming exceptionally difficult for users to stay up-to-date on the latest application. Therefore, a need exists for AIT "consultants" throughout the Navy, similar to commercial sector systems integrators.

Recommendation

DSDC should be designated as the military's system integrator for AIT. The agency's knowledge of DoD operations and standards, as well as its technology base in AIT, would allow DSDC to perform a three-fold roll: educator, systems analyst, and technical advisor.

#### 4. Standards

Reduced budgets and downsizing are forcing the Navy, and DoD in general, to become more efficient. Increasingly, this means interservice and international interoperability among most systems. In that regards, the development of a DoD-wide standard for AIT is necessary. Additionally, the increase in AIT vendors has created a huge variation of system components in the market. Without standardization, different systems could be functionally useless together, thereby misusing ever declining defense resources.

Recommendation

DoD should work with civilian agencies in order to implement a standard for those AIT's without one, including RFID. Additionally, AIT procurement should be based upon non-government standards and commercial-supplied items to the maximum extent practical.

#### 5. Advance of Private Sector AIT

Commercial industry has surpassed the DoD in R&D spending. This difference means that increasingly more of the United States' technological momentum will be based on what's coming out of the private sector. Leveraging these commercial technological

advances to create military advantage is critical to ensuring that our military equipment remains the most advanced in the world. Therefore, a tighter relation with commercial industry needs to exist in order to shorten the cycle time for defense system development and insert technological improvements into DoD systems.

Recommendation

DoD should implement dual use technology in AIT defense procurement whenever feasible. This could be accomplished by: investing in technologies critical to military applications, integrating military and commercial production, and inserting commercial components into military AIT systems. Leveraging commercial technology enables DoD to harness state-of-the-art systems without having the taxpayer make the entire investment.

### 6. Acquisition Issues

Present and future acquisition of AIT systems is perhaps the most important issue for implementation of the technology within the Navy. As such, three elements must be addressed in order for any AIT effort to be a success: funding, integrated logistics support, and system architecture.

Available funding for AIT development, maintenance, and modernization is scarce. While the Navy tries to keep pace in the quality of its equipment, money available for use has been drastically cut. Therefore, the normal process of new technology development presents a dilemma. The Navy wants to add new capabilities while modernizing its AIT systems, but cannot be confident that budgets will be met.

Integrated logistics support (ILS) focuses on integrating support into AIT systems design early in the acquisition process. Since the complexity of today's AIT systems have made them more difficult and expensive to maintain, the execution of a sound integrated logistics support program becomes even more essential. ILS elements range from manpower requirements to computer resources support and should be considered over the entire life cycle of the system.

In addition to cost savings achieved through a well-planned ILS program, architecture design can also be a source of considerable savings. If the system is properly structured, then hardware components can be added or upgraded without expensive changes to the rest of the system. All too often the focus is placed on achieving initial requirements for systems and little though is given as to being able to adjust to what the system may be required to do five years later.

Recommendations

DoD should utilize their Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs to the fullest. These programs enable a modest monetary investment to harness the innovative talents of our nation's's small technology companies. As funding for R&D continue to decline, these programs offer the DoD the opportunity to improve AIT technology while prudently using taxpayer dollars.

ILS and system architecture issues can only be addressed through vigilance and an understanding of their importance to a successful acquisition process over an AIT system's entire life cycle. Therefore, DSDC, acting as DoD's AIT systems integrator, should maintain close watch over all AIT support and technical issues.

## C. RECOMMENDATIONS FOR FUTURE RESEARCH

### 1. Monitor AIT Developments

As discussed throughout this thesis, AIT is an ever-expanding technology. It would be valuable to conduct at least annual research on the technology's latest developments, applications, etc. This would continue to expand the awareness of AIT and further serve to improve the military's logistics network.

### 2. Standards and System Interface

The issue of standardization across the services, commercial sector, and international allies is vital to the continued success of the military's logistics system. Future research might focus on how well standardization efforts have progressed with respect to AIT implementation. A related study should also be conducted concerning AIT's interface with existing and emerging information systems such as the Global Transportation Network (GTN), Worldwide Port System (WPS), and the Global Command and Control System (GCCS).

### 3. Education and Training Efforts

The value of training should not be underestimated. Training intended to show the correct use of the system is also an avenue to inform the user of the benefits of the system. Additional research should be conducted on AIT training efforts that have and have not been successful, thereby identifying strategies to address future requirements.

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